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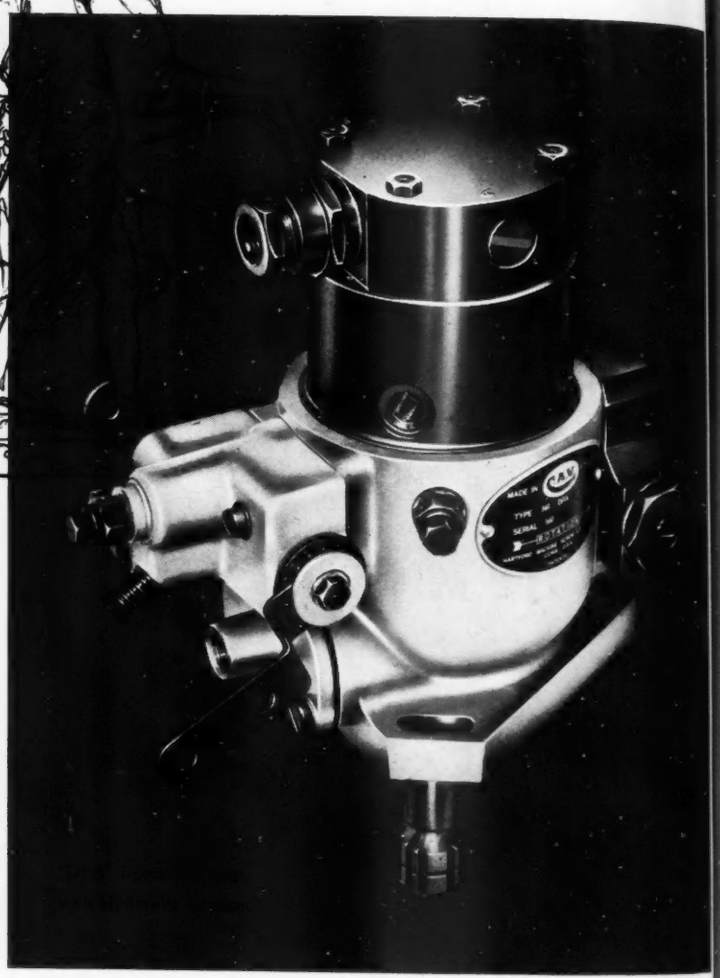

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ENGINEERING

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Mechanics of the Universe

ENGINEERS have come to regard mechanics as their own primary discipline; they have even named a branch of their calling mechanical engineering; but mechanics largely owes its origin and basic principles to the rationalisations of astronomers. It is not surprising therefore that an eminent engineer should return to the fundamentals of his profession and formulate a theory of the universe. Last week Professor R. O. Kapp outlined his views on "The Origin of the Planetary System."

Professor Kapp chose as his starting point the basic requirement for a physical theory that it should involve a minimum number of assumptions. In other words, exceptions, such as an omission in the periodic table of elements, were inadmissible; and theories employing such words as "any" and "every" were preferable to those in which "usually" or "most" appeared. It followed that a theory of the universe in which creation and extinction occurred at any time, or continuously, was more tenable than one in which a finite beginning and end were supposed. The third possibility, that the universe had always existed led, he contended, to the unacceptable conclusion that it must by now have reached a permanent equilibrium. Thus matter, in the form of hydrogen atoms, was continuously appearing and disappearing in accordance with what Professor Kapp described as "the symmetrical impermanence of matter."

Next he pointed out that the creation of matter involved the creation of space, and conversely. At the same time extinctions would naturally occur more frequently in regions where there was a greater concentration of matter, so that in the neighbourhood of a massive body there would be a rapid extinction of matter and an associated contraction of space. This contraction would give rise to that distortion or curvature of space which Einstein has identified with gravity. Hence the more massive a body the greater its gravitational field.

Then Professor Kapp went on to consider a binary system, in which two stars revolved round one another. The more massive star would attract an increasing share of the hydrogen being created in the surrounding space, so that its mass would grow at the expense of its companion, which would not acquire sufficient new hydrogen to make good the losses through extinction. This process, plus the synthesis of helium from hydrogen, which is accompanied by a loss of mass in fusion, would eventually lead to the collapse of the smaller star and hence to the formation of the heavier elements as a result of the enormous pressures and temperatures created. The angular velocity of the star would also have increased as the star itself contracted, until eventually centrifugal force exceeded the diminished gravity and solid pieces would have been flung off to enter orbit round the larger star.

Hence the solar system. But what about the remains of the parent star? It could not, he said, have been sent flying into space by centrifugal force, since the centre of mass of an isolated system remains fixed; thus if the planets are still here, their parent must be also. Professor Kapp's cavalier dismissal of centrifugal escape was, however, somewhat unjust, since a spinning body might conceivably divide into two roughly equal parts, both of which might fly from the vicinity of the solar system, leaving behind their centre of mass and a few odd fragments. However, in Professor Kapp's view, the lesser star is still with us. It is the planet Jupiter.

The Earth too, according to Professor Kapp, is losing mass, and its circumference diminishes by some 25 mm a year. This figure may be calculated from the value of 4×10^8 years he estimates to be the half-life of matter. Thus the Earth was once many times its present mass, and its gravitational field correspondingly greater. At that period the air would have been far denser than it is now, and winds would have been devastatingly violent. That, he maintained, was why life started in the sea—though there are surely much more cogent reasons.

Indeed, the test of a theory was its explanatory power. Once, when gravity was greater, animals would have been smaller—as was Eohippus, the horse's predecessor. The disappearance of the great reptiles was possibly due to the increasing rarefaction of the atmosphere, which failed to provide sufficient oxygen for their enormous bodies. But in the light of Professor Kapp's previous remark, why should they have evolved at all, particularly their armoured land-borne relatives? And what about the pterodactyl in those fearsome winds?

But the theory is attractive and, given confirmation, there can be little doubt of its potential usefulness in prediction and analysis. It is a warning to the astronaut that the crust of the moon may be a sponge of dust, too insubstantial to support his weight; on Earth it may assist the geologist in his search for oil and minerals. Theories of the universe are not without implications for the ordinary man.

Cover Picture.—*Hermetically sealed refrigerator units in the spray booth before passing through a leak test tank at the maker's works. Subsequently the complete refrigeration units go to temperature and humidity-controlled rooms for performance tests and then to isolated compartments for noise-level checks.*

* * *

Plain Words

A consulting engineer I met recently told me of the leisurely, gentlemanly life his father led before 1914. In those legendary days, when the lights were still on all over Europe, the old man (middle aged then) would prepare for his summer holidays with admirable foresight.

His most important clients were in South America. Towards the end of July or beginning of August, he would write them all exceedingly long, difficult and highly technical letters. It took three weeks for the letters to reach his clients; another three weeks for them to understand the letters and reply; and a third three weeks before the replies came in. Meanwhile, on 10 August, the old man set off with his guns for the Scottish moors. Once there, only occasionally would a matter requiring his prompt decision be sent from London, and he would write on the papers " Agreed " or " No " or whatever written words of command he favoured. Sometime in September he would be heard to say that he had had an urgent call from the office and must return on important business, but it was not until two or three days later that he boarded a train.

I relish this story not simply for its Edwardian atmosphere but because it shows up our own folly in the abuses of modern communications. Fifty years ago, if a nut worked loose in some tropical outpost, the local boys set to and tightened it, but now a cable is dispatched to London or New York asking for an engineer to be sent out immediately. And the engineer who is at the mercy of these becks and calls keeps a bag packed, ready to fly out on the first available plane. Last year, one of the sons of that Edwardian gentleman covered 95,000 miles visiting clients. Even such a simple instrument of communication as the telephone is abused—by the thoughtless and by the timid who are afraid to put anything in writing.

The prize, however, goes to the American lady who recently flew the Atlantic for the sole purpose of buying four copies of *The Times* and returning with them to the United States. This trivial travel would qualify her to win a quiz competition.

I give up. Clearly, there is no limit to the misappropriation of the marvels of science and engineering. How long will it be, I wonder, before a television producer arranges for a bridal couple to be transported to the Moon so that the marriage ceremony can be presented on our screens?

The fog is coming down again in London: I must not be late leaving the office.

CAPRICORN

Weekly Survey

Look Round Before Settling

According to figures released recently by the Board of Trade, there has been no great rush for companies to take advantage of the loan and grant facilities now available under the Distribution of Industry (Industrial Finance) Act passed last July. Up to 11 February the Development Areas Advisory Committee which advises the Treasury in these matters had received only 80 claims. It had approved 22 of them and rejected 27 and is still considering 31.

Part of the answer to the slowness of the response may well have been the lack of knowledge about the facilities. Since the Parliamentary Secretary to the Board of Trade sent out his 50,000 letters to managing directors, 351 inquiries have been received up to the time of counting. This is more than came in during the whole first six months of the Act.

It is doubtful, however, if this is the whole answer. Boards of companies do not decide to go into localities where there are special inducements until they have decided if they are going to expand at all. It would be very surprising indeed if the recent recession in the capital goods industries could be offset to any significant extent by a rush of applications for assistance to expand in industrial areas and at seaside resorts. The critical stage for the Act will be when the " climate of investment " improves.

To judge from the latest investigation by the Federation of British Industries, the expectation of future capital investment continues to show a decline, though a smaller one in the last four months than in the previous four months period. The number of inquiries by the advisory committee will indeed probably be a pretty good indication of the strength of businessmen's confidence in an industrial revival.

Advanced Operational Research

A two-week course on operational research is being offered by the London School of Economics and Political Science of the University of London, in conjunction with the Operational Research Society, from 6 to 17 April. The object is to provide " an intensive survey at an advanced level of operational research methodology and techniques." The emphasis will be placed on business and industrial applications. It is intended for graduates or persons with equivalent qualifications and with operational-research experience. The teachers will be members of the staff of the London School of Economics and senior industrial research workers.

This will doubtless meet a need in industry, particularly among those operational research workers who have been pioneering the application of their specialised approach to the solution of problems in a particular firm or industry. The stimulating experience of meeting one another, and the refreshing effect of a return to basic theory should be well worth while. In addition there will be a great deal to be gained from a fresh and discursive study of specific applications in this country and abroad. The library of the LSE will be available to course members and those who wish to take advantage of residential facilities will be able to do so at the school hall of residence—Passfield Hall, Endsleigh Place, WC1. The inclusive residential fee is £65 and the non-residential fee £50.

The course will be conducted from Mondays to Fridays inclusive, in the two weeks. The morning sessions will be devoted to formal lectures and the afternoon sessions mainly to case study work. For case studies, course members will be divided into small groups. Informal evening discussions are also to be included in the programme.

Underlining the point that the course is intended for those already grounded in the subject, LSE suggest three books for preliminary reading: *Introduction to Operations Research*, by C. W. Churchman, R. L. Ackoff and E. L. Arnoff (Wiley, 1957); *Operations Research for Management*, by J. F. McCloskey and F. N. Trefethen (Johns Hopkins Press 1954); *Operations Research for Management II*, by J. F. McCloskey and J. M. Coppinger (Johns Hopkins Press, 1956). The course content includes problems of supply and production, sales distribution and transport; stock control, mathematical programming and scientific method (measures of the effectiveness and the relevance of economics).

Hirsch Succeeds Armand

The resignation through ill-health of M. Louis Armand as president of the Euratom Commission will be received with considerable regret. He is widely known as the man who built up the French railways to their present state of efficiency. In this country he became known as one of the " three wise men " in the discussions which led to the publication of *A Target for Euratom* a few years ago.

His successor, M. Etienne Hirsch, was trained as a mining engineer. From 1924 onwards he held various posts both on the research and administrative sides of the Ethit-Kuhlmann Chemical Company. For a part of the war he was chairman of the French Supply Council in London, a period of service to which he owes his facility with the English language. Since 1952 he has been commissioner general of the French Reconstruction Plan. This is the body, originally known as the Monnet Plan, of which M. Jean Monnet was commissioner general until he became president of the High Authority of ECS. Under the plan, French industrial investment was concentrated first on coal, transport, steel and cement, and agricultural equipment, and then later on housing, manufacturing industry and agriculture.

After M. Monnet's departure for Luxembourg, M. Hirsch has had the direction of the plan. He is well used to seeing energy problems both in total and over the long-term. As a former associate of M. Monnet it goes without saying that he is a firm believer in European integration. With his record as a successful administrator both in the government service and in industry, he should make an ideal president at a time when Euratom as an organisation has still to find its feet. In the first instance the appointment is only to 9 January, 1960, the remainder of M. Armand's term.

Piping Coal

Experiments have been under way in this country for some years on the hydraulic transport of coal, but there is little doubt that much greater progress has been made in other countries. Attention was drawn to this recently by Sir Harold Hartley in an address to the Pipeline Industries' Guild. A scheme has been in operation in Ohio for nearly a year whereby a slurry of crushed and screened coal is pumped through a 10 in pipeline for 110 miles. The pipeline runs 4 or 5 ft underground and delivers directly from coal mine to power station. Transport costs are about 75 cents a ton lower than comparable figures for rail transport.

There has also been a strong interest in Russia

both in hydraulic mining and subsequent pumping of coal to the pithead. Experiments in this country have so far been largely directed towards the transport of lump coal which poses particular problems at the point of coal inlet. Sir Harold suggested that provided the main conditions of a steady flow of coal from an individual mine to a large consumer over a period of years could be fulfilled, and also that the consumer used powdered coal, the adoption of this method of transporting coal could give substantial economies in this country. The transport of coal to power stations at present costs about £18 million a year.

The essential condition to be satisfied before great lengths of pipe for transporting solids are laid is that there should be no possibility of a solid plug being formed at any point; such a blockage could lead to very considerable expense if the pipes were laid underground.

Weizmann and Technion

The second decade of Israel's nationhood opens with a good deal of progress already made on the training of scientists. Last year teaching courses aimed at Ph.D. degrees were begun by the Weizmann Institute of Science when it opened its Graduate School of Natural Science at Rehovot. The school at Rehovot was established to carry out basic research and to supply Israel with scientists trained to do research work. The Weizmann Institute began as an extension of the Daniel Sieff Research Institute but has since developed beyond organic chemistry into mathematics, physics and biochemistry.

Israel's technical university is the Technion, which was established in the very early days of the Zionist movement while Palestine was still under Turkish rule. Today it has 3,000 students enrolled in 12 faculties and departments with a further 4,000 students registered for extension courses. A programme of theoretical and applied research is carried out which is related to the industrial and agricultural needs of the country. It follows from this that there is some emphasis at the present time on civil engineering and architecture. There is a wide programme of work carried out in electrical, mechanical and aeronautical engineering and a Farm Machinery Institute operates in association with the institute's department of agricultural engineering.

State Sale—Everything Must Go

State shareholding, nationalisation and workers shares are all being discussed at the present time in the light of a possible election. In Germany the same ideas are being looked at from the other end of the telescope. The State already owns a variety of industrial firms ranging from giants like Volkswagen and Salzgitter (iron and steel) down to quite small units such as a printing works and a tug-boat company. The interesting thing is that it doesn't want them. All of them came under state control after the war, mostly being handed straight over from Allied control. But in Dr. Erhard's policy of free competition there is no room for state-controlled firms. So a Ministry of Federal Property has been set up whose job is to dispose of some £500 million worth of industrial enterprises.

The first company to be sold is Preussag, a big non-ferrous metal manufacturing firm in Lower Saxony. The announcement of the issue of Preussag shares has given rise to a great deal of discussion. This is an issue of " workers " shares.

To make sure they are in fact fair shares, only those with incomes of under £1,326 a year are allowed to buy, and the allotment per worker will be five shares. Nobody seems to care very much for this proposal. The trade unions say that there is nothing to stop big business buying the shares from the workers and gaining control of an important plant. This will be made all the easier by the fact that the issue price will be well below the present market value. The middle classes, who do not qualify as buyers, complain that national assets are being squandered. Business men say that with so many shareholders it will be impossible to hold an annual meeting anywhere except in a sports stadium. However, Dr. Lindrath, the minister concerned, is pressing on with his scheme. He even hopes to sell the Volkswagen works one day. But first he has the difficult task of proving that it belongs to him.

Looking Down at Clouds

The United States Navy have put a satellite into orbit to study clouds. It was launched by Vanguard rocket on 17 February and has two photocells that register the variations in light intensity received from a 40 sq. mile patch of the Earth's surface below it. Since clouds reflect light extremely well in comparison with land or sea, the principal variations in output from the cells indicate variations in cloud density. In fact the engineers who planned the experiment expect that, after a number of encirclements of the earth, the satellite will provide them with a rough picture of the cloud distribution between latitudes 35° N and 35° S—the region below the satellite's orbit.

This is an early, relatively simple, experiment and will last for a month at most, after which time the satellite's batteries will no longer operate. But it is likely that the technique can be extended for long-term weather prediction, which is of considerable economic importance, assuming the forecasts are reliable.

Signals from the photocells are stored during orbit on magnetic tape and transmitted in bulk on the receipt of a command signal from the ground. Initial calculations showed the orbit to vary between 335 and 2,050 miles, with a period of 126 minutes. Such parameters indicate a very long life. The satellite, called Vanguard II, is a 21 lb sphere of 20 in diameter.

Foundation for Tropical Industry

The Tropical Products Institute is to become a research station of the Department of Scientific and Industrial Research, following the decision to transfer the responsibility for the TPI from the Secretary of State for the Colonies to the Lord President of the Council as from 1 April. The Institute had its roots in two quite different bodies—the plant and animal products department of the Imperial Institute and the Colonial Products Research Council. The work of these two was combined under one director in 1953 when its name was changed to the Tropical Products Institute.

The main reason for this change, according to the official handout, is the changing nature of the Commonwealth itself. Countries which have reached independence and are, therefore, no longer closely connected with the Colonial Office may still wish to use the Institute. It has, therefore, been moved under the control of the DSIR whose minister, the Lord President, has wider responsibility for research in the civilian field. Support will continue to be provided to the Institute by the Colonial Development and Welfare Funds for work of primary interest to the colonies.

The terms of reference of the Institute, which are now in effect transferred to the DSIR, are exceedingly difficult to fulfil. Its aim has been to improve the technology of industries already in under-developed areas and to introduce new industries following research into tropical plants and animal products. Particular attention is to be given to the needs for diversification in the territories which have an economy based on one crop only.

Letters to the Editor

POWER FROM HEAT DIRECT

SIR, May I refer to the Weekly Survey note under the above heading on page 98 of your issue of 23 January?

The writer appears to be under the mistaken impression that " the entire life " of a radioactive fuel is twice the half-life. He states that " the entire life " of polonium is 276 days, presumably because the half-life is 138 days. May I point out that if half the polonium has decayed in 138 days, then half of what is left will decay in the next 138 days, and that means that after 276 days only three-quarters of the polonium will have decayed.

The life of the battery using polonium as a heat source will not be 276 days (except by chance); it will probably depend on the voltage sensitivity of the circuits that it feeds.

Yours faithfully,
R. G. TEE.

102 Buck Lane, London, NW9.
20 February, 1959.

Editor's Note:—The writer is of course quite correct as to the meaning of half-life, but in the published accounts of the American experiments, the *working* life of the polonium power source was given as twice the half-life; presumably the figure has been arbitrarily chosen as the period during which a useful output can be obtained. At the end of the *radioactive* life of the polonium, the power output would be approaching zero. In the words of the official US statement: "Polonium 210 has a half-life of 138 days and during two half-lives (276 days) the device would produce a quantity of electricity equal to the output of 1,450 lb of the best conventional batteries now available."

IS JARGON NECESSARY?

SIR, Is it not time that something was done to restrain the unlimited multiplication of jargon?

The following is quoted from an address on " Geology," by Professor L. R. Wager, F.R.S. (*The Advancement of Science*, vol. XV, No. 58, Sept., 1958, p. 37):—

" It was shown by Hess (1939) that the olivine of peridotites associated with gabbros, here called the autochthonous olivine cumulites, was more iron-rich on the average (Fo86), than those from alpine type peridotites (Fo90). While it is likely that the olivines of the autochthonous cumulites are usually the more iron-rich it is apparent that some are not. Thus the autochthonous cumulites of Rhum, particularly the harrisites, may contain olivine which is Fo89, and olivine from an autochthonous dunite forming part of a small layered mass near the Skaergaard intrustion, East Greenland, is Fo92."

Yours faithfully,
G. M. BOYD.

124 Goodhart Way, West Wickham.
19 February, 1959.

CLEAR THINKING NEEDED

SIR, Although I have probably not seen all the correspondence on this important subject, I have not noticed any mention of two highly influential organisations with ample resources which might be expected to be intensely interested in the promotion of first-class ideas. I refer to Aims of Industry Limited, of 5 Plough Place, Fetter Lane, EC4, and the Institute of Directors, of 10 Belgrave Square, London, SW1.

Both these bodies are, I think, intimately associated with commerce and industry throughout the country. The former may be said to be the " publicity organisation for *free* enterprise," as distinct from " *controlled* socialism "; the latter being that body of men who are largely responsible for initiating and putting into effect any policy likely to be of advantage to their respective companies, in every branch of industrial and commercial activity.

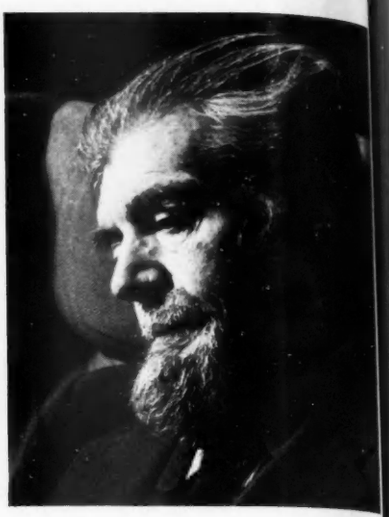
I would have thought that either or both of these influential bodies could do an immense amount to further the adoption of suggestion schemes and formulate a *modus operandi* as a basis from which to work.

Yours faithfully,
HYDE C. BURTON.

2 Court Royal Mansions, Brighton, 7.
21 February, 1959.

Obituary

DR. T. L. ECKERSLEY *Pioneer of Radio Wave Propagation*



Dr. T. L. Eckersley, F.R.S., one of the most notable research workers of this century, died on Sunday, 15 February, after a number of years of ill-health.

Thomas Lydwell Eckersley, who was born on 27 December, 1886, achieved recognition comparable to that of his famous grandfather, Professor Thomas Huxley, through his profound contributions to the theory and practice of radio-wave propagation, which have done so much to advance modern radio communication and radar engineering. Among Dr. Eckersley's outstanding achievements have been his brilliant prediction of the performance of short-wave services, including the enunciation of a theory of the diffraction of waves round the earth taking into account the earth's resistance, and the application of phase integral theory to propagation problems. By another method he produced a theory of propagation in the ionosphere, and his experiments in connection with the interpretation of random echoes from the ionosphere led him to his now well-known theory of scattering. He was also the first to employ the method of spaced frames to achieve a direction-finding system substantially free from polarisation errors.

Dr. Eckersley was educated at Bedales School, University College, London, and Trinity College, Cambridge. He joined the National Physical Laboratory in 1910 and in 1913-14 took part in the Egyptian Government Survey. During the First World War he served with the Royal Engineers in Egypt and Salonika on wireless intelligence where his theoretical work on " night effect " and coastal refraction served to lay the foundation of his subsequent career. After the war he joined the Marconi Company and began his research into the resistance of transmitting aerials, one result of which was a notable increase in radiation efficiency, brought about by the use of earth screens.

During his lifetime Dr. Eckersley received world-wide recognition and was presented with a number of awards, the most notable of which was the Faraday Medal, presented by the IEE in 1951. At the time of the presentation, owing to illness, Dr. Eckersley was unable to attend a London function and, such was the esteem in which he was held by his fellow members of the IEE, the unprecedented step was taken of holding the ceremony near his home.

MR. A. G. M. MICHELL *Lubrication Theory and Practice*

Few engineers have evolved a successful mechanism from an established mathematical theory. One rare exception was A. G. M. Michell, who died on 17 February in Melbourne, Australia, at the age of 88. In the first decade of this century Michell extended Osborne Reynolds' classical theory of lubrication by taking into account the conditions of a finite-size bearing in terms of a pivoted or tilting pad and then developed the bearing which carries his name. His work enabled bearing stresses to be increased from 50 to 10,000 lb per sq. in, thereby permitting immense savings in bearing size.

The success of the Michell bearing had a marked effect on the design of all high-speed bearings, giving them not only a much increased specific loading but also a higher efficiency. His work has been described as having a more profound effect on prime movers, and particularly turbines and propeller drives for ships, than any other single invention. Without it the modern ship might have been an impossibility.

Following the advances made in thrust and journal bearings Michell turned his attention to the high-speed engine and the limitation of the crank-pin bearing. In 1917 he invented his crankless engine. By 1925 a number of these engines had been operated successfully in Australia for air and gas compressors, diesel engines and internal combustion engines generally. Despite many attractive features, notably compactness, progress was slow when compared with that of the thrust bearing and in 1932 Michell left the engine with the Michell Crankless Engine Corporation of New York.

Besides the mechanisms for which he is universally known Michell also invented at different times an impulse turbine, a hydraulic transmission gear which was a forerunner of those used in cars and ships today, a telegraph cipher system, a cipher decoding machine (jointly with H. Clement Newton) and also a workshop viscometer which was another device based on a mathematical analysis.

Michell had the rare distinction—at least it was very rare at the time of his election in 1934—of being an engineer who was a Fellow of the Royal Society. He was also awarded the James Watt International Medal on the nomination of the Institution of Engineers, Australia, the Engineering Institute of Canada, and the South African Institution of Engineers. The medal was presented, in his absence, at a special meeting in London on 22 January, 1943. Such was the importance with which the ceremony was regarded that the BBC broadcast the proceedings directly to Australia where Michell was living and the medal was received on his behalf by the Rt. Hon. S. M. Bruce, C.H., the High Commissioner for Australia. During the course of the citation it was said that Michell's contribution to lubrication theory was a notable mathematical achievement and the only really important extension of Reynolds' theory yet effected.

Anthony George Maldon Michell was born in London on 21 June, 1870, while his parents, who had emigrated to Australia 17 years previously, were visiting this country. Both his parents came from families that had been engaged in Cornish mining for many generations and his father worked in the gold mines of Victoria. He received his first education in Australia before returning to England in 1884 in the company of his elder brother, John, who was an undergraduate at Trinity College, Cambridge. (John afterwards became an assistant professor of mathematics at the University of Melbourne.) At Cambridge Michell attended the lectures of J. J. Thomson as a non-collegiate student before returning to Melbourne University, where he graduated in engineering in 1895. His university awarded him their Kernot medal in 1938.

After gaining early experience in structural and hydraulic engineering as a surveyor and assistant engineer, he became principal assistant and then partner of Bernard A. Smith, a consultant specialising in hydraulics, especially the design of water turbines. From this partnership came the Smith-Michell regenerative centrifugal pump which was widely adopted for use on irrigation schemes. In 1903 Michell started to practise in Melbourne on his own account and then began the work that was to make him famous. He possessed, however, many relaxations outside his professional work. He was a botanist of no mean order, a keen farmer, and a deep reader who built himself a fine private library.

PROFESSOR A. H. GIBSON *Hydraulic Engineering*

Professor A. H. Gibson, Emeritus Professor of Engineering in Manchester University, died at his home in Cheshire on Tuesday, 17 February. He was 80.

Gibson's main interests lay in hydraulic engineering and he will be remembered by several generations of engineering students for his textbook *Hydraulics and Its Applications*, which became a recommended book at many colleges. In 1925 he became a member of the sub-committee which was appointed to inquire into the practicability of a barrage across the River Severn as part of a hydro-electric power project. This sub-committee decided in 1926 to arrange for the construction of a hydraulic model of the Severn estuary with the object of determining the general effect on the estuary of the introduction of a tidal barrage, and the construction of the model was undertaken in the engineering laboratories of Manchester University under Gibson's supervision. The model must rank as one of the best-known of all the hydraulic models ever built and Gibson will be remembered longest for his work on it and the subsequent reports.

It was first put into operation in March, 1927, and the results of running it for a period equivalent to some 500 years in the actual estuary were recorded by him in a report dated May, 1929. A series of additional observations were described in a second and final report in October, 1932.

Born on 26 July, 1878, Arnold Hartley Gibson was educated at Rishworth Grammar School, near Bradford, Yorkshire, and served his apprenticeship in mechanical engineering, also gaining drawing office experience in this country and the United States. After graduating B.Sc. at Manchester in 1903 he was for a short time head of the mathematical department at the then Salford Technical Institute, afterwards becoming assistant lecturer in engineering and hydraulics at Manchester. In 1909 he was appointed professor of engineering at St. Andrews, and remained in that position (apart from war service in the Royal Field Artillery and at the Royal Aircraft Factory) till 1920 when he returned to Manchester. In 1921 he was president of the engineering section of the British Association and his address was concerned with water power developments throughout the world. In 1939 he was awarded the James Alfred Ewing Medal of the Institution of Civil Engineers. He had contributed several papers, covering many facets of hydraulic engineering, to the Institution and had received both a Crampton Prize and a Telford Premium.

Plant and Equipment

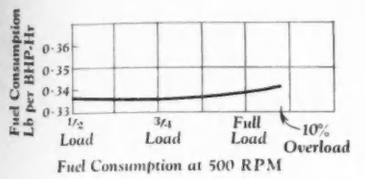
MEDIUM SPEED DIESELS

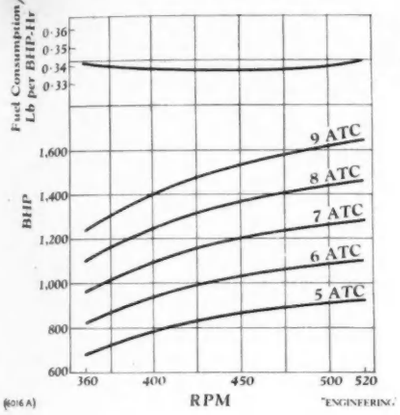
A new range of industrial and marine diesel engines has been added to those made by Ruston and Hornsby Limited, Lincoln. Unlike most additions, they are not developments of existing types but have been designed from first principles; some details of their more interesting design features will be given in a subsequent article.

The AT series covers the power range from 600 to 1,645 b.h.p. at speeds up to 520 r.p.m. (industrial) and 500 r.p.m. (marine). Bore and stroke are 12½ in by 14½ in and cylinder numbers are from 5 to 9, with in-line construction. Two versions are available, both pressure charged but with or without intercooling. In those with intercooling (code letter C) the maximum service b.m.e.p. is 160 lb per sq. in, and the maximum cylinder pressure 1,200 lb per sq. in. Fuel consumptions down to 0·34 lb per b.h.p. per hr, and better, are normally obtainable in service. The 9ATC engine weighs 29¾ tons (net) giving a power to weight ratio of 40·7 lb per b.h.p. Performance curves for the intercooled industrial version are given in the accompanying diagram.

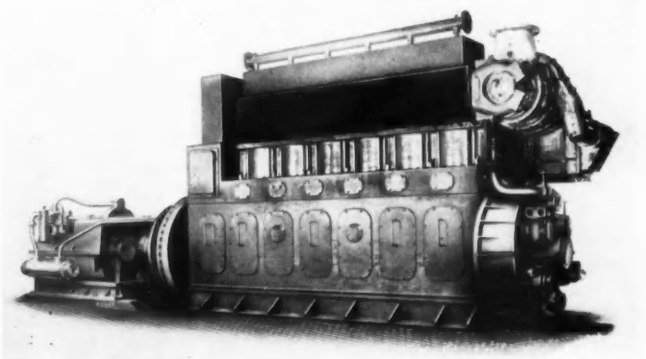
The other illustration shows the marine version with a dummy standard gearbox casing shown in position for comparison. The drive from the flywheel is through a Metalastik Metastream coupling. At the forward end is a drive case from which six auxiliaries can be served; their shafts are driven from a single central gear mounted on the crankshaft, and of resilient construction.

Crankcase, cylinder block, and cylinder head are cast iron with the camshafts mounted at head level. There are thus no push rods. The casing surrounding the valve gear and camshaft is fabricated. There are four valves in each cylinder and the injector is centrally mounted. Four bolts hold the head in place—design studies and tests have shown that this arrangement gives a secure seal up to 3,000 lb per sq. in. It also allows freedom for the arrangement of the cooling and of the inlet and exhaust porting, now on opposite sides of the engine. Pistons are of cast iron and the connecting rods and crankshafts of forged steel. The engines are designed to burn fuels in the Class A and B ranges.





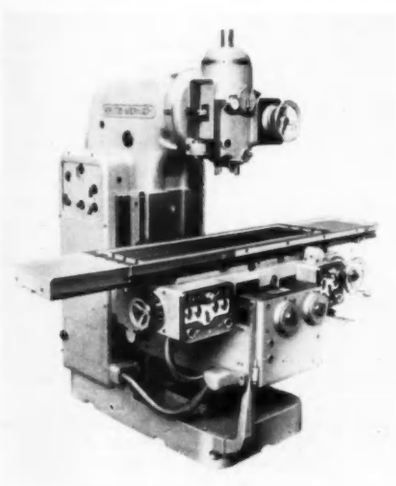
Performance curves for the AT range of industrial diesels with intercooling.



The 6ATM engine with dummy gearbox in place, and showing auxiliary drive fitting.

MILLING MACHINES WITH FINGER TIP CONTROL

New developments in milling machines by Fritz Werner are being exhibited by the Rockwell Machine Tool Company Limited at their Welsh Harp, Edgware Road, London NW2, showrooms from 9 to 20 March and at Cateswell Road, Hall Green, Birmingham 28, from 7 to 17 April. The main features of these machines are that all motions are controlled by switches or push buttons instead of handwheels; they employ hydraulic clamping for slides, and offer instantaneous selection of feeds while cutting. Model FV2D is shown on the left.



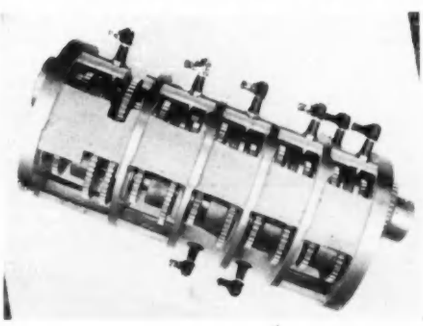
Finger tip electrical controls are a feature of the new Werner milling machines.

The table motions and feeds are engaged by electromagnetic multiple disc clutch units of the type shown in the illustration on the right. Sequence operation is obtained by the use of table stops which allow many different cycles to be set up on the selector switches. For example, the cycle can be set for continuous cycle milling with rapid traverse and automatic indexing with the addition of skip feed if required. Equally it is possible to set up the machine to mill a rectangular opening under fully automatic operation. All slides not in use are automatically clamped.

On the larger machines there is hydraulic selection of cutter speeds; the clutch is freed by pressing the central control and the dial turned to indicate the chosen speed. A separate hydraulic motor rocks the spindle slowly till the gears mesh, when final engagement takes place by hydraulic pressure. It is this last pressure that governs the action of the rocker motor.

The electrical control elements are mounted on swing-out frames within the main column. Most of the relays are identical making for ease of maintenance and may carry spare lines. Interlocks prevents the use of power feeds when the manual control handle has been engaged. Power feeds are also cut out of the spindle stops, nor can they be engaged while it is stationary.

The range includes automatic and semi-automatic types in both vertical and horizontal forms. Table sizes are from 28 in by 9 in to 91 in by 20 in. Simpler machines are also available for production work.



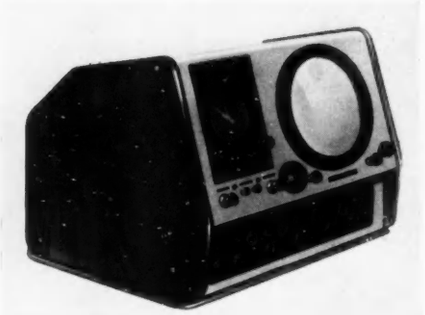
Multidisc electromagnetic clutches engage the feeds.

Continuing **Plant and Equipment**

UNIT SYSTEM FOR MARINE RADAR

A new concept in marine radar—the unit system—is being introduced by Kelvin and Hughes (Marine) Limited, St. Clare House, Minories, London, EC3. From a range of three basic units the ship-owner is now able to select a complete equipment which will best suit his economic and operational needs.

In the Kelvin Hughes unit system a choice of four basic display units is available to operate in conjunction with a transmitter/receiver and scanner, common to all sets. All are designed to comply fully with the 1957 Specification of the Ministry of Transport, and incorporate printed circuits, which Kelvin Hughes pioneered in the marine radar field. All circuits are unit-constructed to provide maximum accessibility for servicing and for rapid replacement.



True plot display units, above and right.

For the Kelvin Hughes unit system a development of the Type 14 transmitter/receiver has been chosen. This is a high power transmitter It has been thoroughly tried and tested over the past two years in several hundred vessels of all classes. The saving in both power consumption and production cost which would be provided by a lower power transmitter is insignificant, and therefore a high power transmitter is offered with even the lowest price equipment, to ensure " big set " performance. The transmitter has a nominal peak power of 60 kW, the pulse duration is 0·1 or 0·3 microseconds, automatically selected by range switch; recurrence frequency 1,100 p.p.s. A neon lamp tuning indicator facilitates tuning of the local oscillator, and a built-in performance monitoring device is included. The receiver is a superheterodyne, with reflex klystron local oscillator, coaxial crystal mixer, and tunable wideband TR cell. The klystron output is fed to the crystal mixer by a directional coupler. I.F. of 60 Mc/s is fed from the crystal mixer through the preamplifier and main I.F. system, the overall bandwidth being 10·5 Mc/s.

Kelvin Hughes were the first company to introduce the slotted waveguide type of scanner, and it is still the only slotted waveguide in general marine service today. The ability to distinguish two targets close together at the same range is almost entirely dependent on the scanner. It also determines the freedom or otherwise from misleading echoes caused by side radiation, which also causes in loss of picture clarity especially at the shorter ranges.

The slotted waveguide scanner is light in weight, and has a low windage. Its extremely low side radiation makes it suitable for both large and small vessels. A high-performance scanner of this type is particularly essential for the smaller vessel where picture definition at short ranges in close waters is important. It has a horizontal beamwidth of 1·2° to half power points, and vertical beamwidth of 27° to half power points. For two-way propagation the maximum side lobe power is considerably less than 0·01 per cent of the power of the main lobe. The scan is clockwise, continuously through 360° in azimuth at 20 r.p.m.

A choice of four display units is available to operate in conjunction with the transmitter/receiver and scanner units. Facilities are also provided to enable two display units to be operated simultaneously from a common transmitter and scanner system.

Two of the display units available are of a new type, offering a choice of relative and true motion presentation The additional information derived from the true motion type of presentation is obtained from the movement of a target vessel across the PPI screen. This is commonly obtained by observing the afterglow trail behind the target vessel. Exhaustive trials with all types of cathode ray tubes have shown that this is not entirely satisfactory so a tube face reflection plotter, claimed to have exceptional optical characteristics was developed.

With its aid, true plots of own and several target vessels can be easily kept by the navigator without interfering with his normal watch-keeping duties. In this way information about the true courses and speeds of target vessels are clearly presented as a semi-permanent record. These displays can also be operated as relative motion displays with own ship off-centred. The advantage is that for a given range scale in use, the range of view in one direction can be increased at the expense of the range of view in the reciprocal direction. This would normally be used to increase the range of view ahead at the expense of the range of view astern.

Slotted waveguide scanner.

Practical operational trials have shown that it is sometimes desirable to operate a second relative motion display as a monitor. In this way the " true plot " display can be used on the shorter ranges for ship avoidance whilst vessels at greater ranges or coastal navigational marks can be observed on the second display.

Careful thought has been given to the operational problem of resetting own ship's position. Visual and aural warning is given when resetting becomes necessary and it can be achieved either manually or automatically.

ROTARY PERFORATOR

A new rotary perforator, scorer and slitter of American design, the Perf-A-Matic, is being introduced by the Machinery Division of Gordon and Gotch Limited, 75-79 Farringdon Street, London, EC4, selling agents for the sole concessionaires, Sulby Engineering Development Company Limited.

The machine is a high speed single-sheet perforator which is equipped with a simple automatic feeder. It is designed to handle commercial stationery and incorporates shear type cutting blades which are available in a wide range of slit sizes. The main advantage of this type of perforation is that it leaves no burr on the under side of the sheet, and there is no female head to be clogged with paper. This feature is particularly important when gummed paper is being processed.

The automatic feeder is capable of handling high running speeds up to a maximum of 16,000 ft per hour, and the machine can be rapidly adjusted when changing from one job to another. Production is further increased by the fact that the feeder takes sheets from the bottom of the stack, so that by providing continuous loading there is an additional saving of time.

The machine will perforate, score and slit simultaneously, and accurate register is obtained by the use of sheet-edge calipers, which control the sheet all the way through the rotary perforators. They also enable accurate perforation to be obtained close to the edge of the sheet.

The setting-up time of the machine is reduced to a minimum by reason of screwless quick-action clamps on the feed and delivery side lays, a simply adjusted automatic feeder and a micrometer control on the front lays for final accurate register. The knives are self-sharpening, and as many as 25 perforating heads can be used at one time if necessary.

The Perf-A-Matic can handle a wide range of stock, from air-mail to board, and will take a minimum sheet size of 3 in by 4 in and a maximum sheet size of 23 in by 25 in. The net weight of the machine is 285 lb and the floor space is 29 in by 58 in. The machine is supplied complete with electrical equipment, two perforating heads, a slitting head and a scoring head and a very comprehensive set of operating instructions.

SPINNING LATHE

Hydraulic Movements and Locking

Now available in this country from the Embassy Machine and Tool Company Limited, 248 Watford Way, Hendon, London, NW4, is the P1b 1200 spinning lathe made by Leifeld & Co., Werkzeug und Maschinenfabrik, Ahlen, Westfalia, Germany. It is shown in the accompanying illustration. Basically the machine consists of a strong, ribbed cast-iron baseplate which is normally sunk into the foundation. This baseplate carries on the left-hand side the headstock with 48 in centre height, having a large tool cabinet at the base. The all-geared headstock gives a total of 18 spindle speeds covering a range from 5 to 525 r.p.m.

The drive is taken from a 17·5 kW 3 phase motor mounted at the rear of the machine, through belts. The heavy duty forged spindle is mounted in a combination of parallel and taper roller races at the front, and plain roller races at the back. The headstock is fitted with oil circulating pump and filter. Control of the motor is through push buttons.

The spindle nose carries a quick action cam lock flange (not shown in the illustration) for speedy and positive mounting of chucks. A short taper at the front serves for precision location. Six studs and nuts on each chuck pass through six corresponding elongated slots spaced around the circumference of the flange and in conjunction with a locking plate, securely retain the chuck.

On the right of the soleplate is the sliding upper bed moving along adjustable guides which enables alteration in the size of the gap to be carried out to suit the blank diameter and depth of finished article. This movement is effected by means of a hydraulic cylinder which avoids having to loosen screws and clamping strips. Moreover, the movement of the upper bed along the soleplate can also be utilised for traversing the spinning roller, in which case, the tailstock barrel moves backwards against the pre-set hydraulic pressure. A second auxiliary cylinder arranged vertically engages and withdraws a locking mechanism by means of which the upper bed can be firmly clamped in its working position. The width of gap with upper bed shut is 16 in, which can be extended to 54 in with the upper bed in the extreme right position. Special machines can be supplied with extended baseplates giving gaps up to 74 in and 94 in.

The sliding bed carries the hydraulic tailstock. The pressure of the hydraulic tailstock is infinitely variable between 0 and 5 tons, the control valve with pressure gauge being positioned at the front; stroke of tailstock barrel is 30 in. The tailstock can be fitted with cross adjustment. A revolving back centre running on taper roller races is permanently mounted at the head of the tailstock barrel, to which the various backplates are bolted. Adjustment of tailstock along the upper bed is by means of ratchet and pinion.

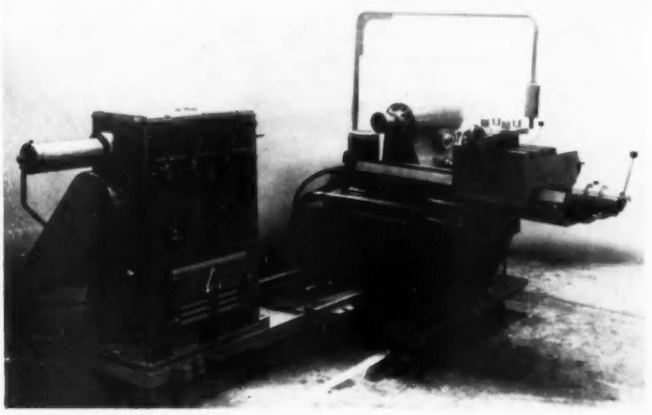
At the front of the sliding bed, provision is made for an apron extension, the foot of which has its own foundation plate. Longitudinal slots in the apron and transverse slots in the extension allow for a very wide range of positioning of the compound rest to suit the type of work in hand.

The heavy duty compound rest is mounted on a swivel baseplate giving a 360° rotation, and is bolted to the apron by means of four clamps and bolts. The longitudinal traverse is along prismatic guides through spindle and nut, power is supplied by a hydraulic motor through 2-speed reduction gearing with fast return. The hydraulic control valve selecting the rate of feed of the traverse movement and change of direction is at the end of the motor housing above the fast return gear lever, and positioned so that the operator is in perfect control throughout the spinning operation. A single lever controls movement in both directions and governs the infinitely variable feed range. In order to avoid hydraulic pressure hoses at the front of the machine, the swivel base of the compound rest has been bored with inlet and outlet and the hydraulic oil then passes through the centre of the pivot pin to the traverse casting and along bores to the hydraulic motor.

The cross-slide of the compound rest is arranged for mechanical as well as hydraulic operation. The two are interlocked so that simultaneous engagement is impossible. Mechanical movement is by means of spindle and nut. Sensitive pressure control enables direct copy spinning to be carried out. For work such as large diameter pans, reflectors or any other part with a gradually changing profile, the roller is guided along the chuck and constant pressure assures accurate following of the contour. In some cases the hydraulically operated cross slide will enable the production of non-circular work to be carried out without such special aids. Alternatively, or in addition to direct copy spinning, the cross slide can be fitted with a hydraulic stylus point and tracer mechanism by means of which copy spinning, in conjunction with a template, can be carried out. The upper face of the cross slide is machined with three T-slots into which square headed bolts with springs and cross bars are placed for clamping the spinning roller. This arrangement is preferred to four fixed studs, as it enables spinning rollers to be clamped at any angle.

The spindle is bored and carries on the extreme left the ejector cylinder which is energised with hydraulic oil. A push rod passes through the centre of the spindle and is fitted with an ejector head for removing parts which are difficult to strip off the chuck.

The hydraulic driving unit is mounted on the sliding bed at the rear of the machine, and travels with it. A 3-stage pump immersed in the oil tank is driven by a flange-mounted motor; the pump stages are arranged so that they cut out successively according to pressure requirements, the lowest stage delivering a very large volume of oil under low pressure for all fast movements, thus reducing idle times to a minimum. The change-over from low to medium and medium to high pressure stages can be set on a control valve and is usually adjusted at the maker's works to cover normal working conditions. For particularly high pressure requirements such as profiling of very sharp contours, the machine can be supplied with armoured high pressure hoses. Under normal working conditions the volume of oil in the tank is such that no excessive heat will be generated. For particularly heavy duty, however, the oil can be cooled, a $\frac{1}{2}$ in copper cooling spiral being provided in the oil tank. The hydraulic system is also provided with bleeding screws to allow the escape of air enclosures. On request, the machine can be fitted with a pendant control mounted on a swivel arm, so that the operator has the entire electric control within easy access. All electric control elements are housed in a separate switchgear cabinet with mains separator and indicator lamp.



The Leifeld heavy duty spinning lathe has both hydraulic and mechanical motions.

TRAFFIC BARRIER

An electrically operated traffic barrier has been designed by Bolton Gate Company Limited, Waterloo Street, Bolton, Lancashire, for the remote control of factory entrances and railway pedestrian crossings.

The standard barrier is supported on rolled steel channel posts by means of self-aligning ball races in rigid plummer block housings. The boom, a 3 in diameter, 14 swg aluminium alloy tube, is counterbalanced by cast iron weights. To avoid damage to the mechanism in the event of the boom being hit by the vehicle, the barrier is designed to swing through a horizontal plane.

Also available is a barrier fabricated from 6 in by 1 in aluminium alloy sections complete with a 1 in by $\frac{1}{4}$ in aluminium alloy under-lattice, which automatically folds flat as the barrier is raised, to give maximum clearance.

Both standard and lattice models are powered by a totally enclosed fan cooled motor driving through a double worm reduction gear. Drive to the barrier spindle is through an overload clutch to prevent damage should the barrier be obstructed during descent. Limit switches which automatically cut-off the motor at each end of travel are incorporated, the whole driven mechanism being housed in a sheet steel case fixed to the main frame.

The barrier is controlled by a push-button reversing starter with built-in isolator which may be operated from inside the gatekeeper's office In the event of a power failure the barrier may be raised by hand.

Companies in the News

Keeping an Eye on Krupp

On 7 January, the High Authority of ECSC, apparently making the best of a bad job, announced that it had authorised the Hütten-und-Bergwerke Rheinhausen AG of Essen to acquire a majority of shares in the Bochumer Verein für Gussstahlfabrikation, of Bochum. Rheinhausen is owned by Friedrich Krupp of Essen. Coming as it did at a time when a clamour was being raised about the fact that Herr Krupp had not carried out his undertaking to sell his coal and steel holdings, the High Authority's decision cannot have done much to increase either its prestige or its authority.

An official statement explains that the decision, taken under the treaty setting up the ECSC, is based only on economic considerations. The chief of these is whether or not the merger gives the firms concerned such a big slice of production that they can restrict competition. In fact only a small percentage of total Community production is involved. The actual figures are hard coal 3 per cent, coke 4·4 per cent, pig iron 5·7 per cent, crude steel 5·5 per cent and rolled products 3·7 per cent. In the High Authority's view these percentages will not give Herr Krupp any undue hold on the market. But as an insurance against possible future dangers they will arrange to supervise any further proposed investments by the firms concerned. In view of the extensions that Herr Krupp has contrived to make to his holdings, while under obligation to do the exact opposite and dispose of them, it looks as though the High Authority of the European Coal and Steel Community has given itself quite a task.

Ruhr Iron

In the middle of the 18th century, when the countryside by the Ruhr was forest, heath and marsh, three small ironworks were established on the territory of the present town of Oberhausen—St. Antony, Gute-Hoffnung and Neu-Essen. When St. Antony, the oldest of them, started production in 1758, the foundations were laid for the creation not only of Gutehoffnungshütte (the company now celebrating their two-hundredth birthday) but also of Ruhr industry. Marsh ores and limonites found nearby were used as the raw materials of iron production. The smelting practice was based on charcoal which was supplied from the pines in the neighbouring forests. Now the GHH group dominates German industry.

GHH production consists mainly of large capital goods and complete industrial plants. Most of the products are designed to suit the specific needs of customers. The secret of GHH's success is, they say, "the close contact maintained with the customer, which permits a continuous exchange of ideas." They are the biggest shipbuilders (Deutsche Werft AG, Hamburg), and the biggest structural engineers. They are also major steel-plant engineers and it is in this capacity that they are currently engaged in India on the construction of the Rourkela steel plant. GHH are members of a consortium who are building a one "million" ton integrated steel plant at Rourkela. They are supplying three 1,000 ton blast furnaces (of American design) and building the pig casting machine.

Danish Diesels Made in USSR

Burmeister and Wain have entered into a licence agreement with the USSR for building new B & W diesel engines. The news of this agreement was released by Burmeister and Wain's managing director, Mr. Niels Munck, when Mr. Anastas Mikoyan, First Deputy Prime Minister of the Soviet Union, visited the company in Copenhagen on the way home from his stay in the United States.

The licence agreement, states the company, can be considered "a natural consequence of the relations which Burmeister and Wain have had for a great number of years with Russia." Since 1932 they have delivered 24 ships from their Refshale Island yard in Copenhagen and supplied a large number of engines for ships now sailing under the Soviet flag.

The B&W—Soviet agreement is a timely reminder that orthodox licensor-licensee relationships can be obtained with the Soviet Union as with other countries. The widely held view that "Russia copies anything worthwhile" may not after all be wholly correct. The time is approaching when Russian products and processes will become available for licence in this country. Oil-well drilling equipment may have been the first instance of any Western company (in this case a United States concern) expressing an interest in a manufacturing licence.

Brazing and Inspection Services

Newton Victor Limited, the X-ray department of Metropolitan-Vickers Electrical Company Limited, has announced a specialised brazing service for industry. The plant available provides for brazing of components in controlled atmospheres and under vacuum, and includes radiation and muffle furnaces giving temperatures up to about 1,800° C, and handling components up to approximately 3½ in square and 10 in long. Eddy-current furnaces giving localised heating and temperatures of over 1,100° C are also available and are capable of handling items up to 3½ in in diameter and 3 ft 6 in in length. The specialised equipment available is used by Newton Victor in the manufacture of X-ray tubes and valves and can cater for joints in stainless steel, steel, copper, and other metals, including beryllium.

Another service to industry has been announced by the Ultrasonoscope Company (London) Limited, who have instituted a technical service bureau to advise on all aspects of ultrasonic flaw detection and inspection. This service will be free, and the bureau will be able to recommend techniques and advise on the possibility of applying ultrasonic inspection to particular problems. The use of ultrasonic methods of inspection has been growing, but Ultrasonoscope believe that they may be able to assist companies having no experience in ultrasonic equipment and its potentialities.

Short Take-Off by Two Professors

The United States Air Force recently announced the acquisition of the first STOL (short take-off and landing) aircraft. Three Helio Super Couriers have been ordered from the Helio Aircraft Corporation of Norwood, Mass. The purpose is "to evaluate operational techniques" of the STOL aircraft.

The aircraft are five-seaters, powered by a 6 cylinder 295 h.p. geared Lycoming engine. It is a small machine, 31 ft long, 8 ft 10 in high and with a wing span of 39 ft. Empty weight is 2,012 lb, and the maximum industrial gross weight, 3,920 lb. It can take off and land fully loaded in less than 75 yards with no wind and has a flying speed ranging from 30 to 176 miles per hour.

The history of the STOL aircraft's development has its origins in the Massachusetts Institute of Technology and the Harvard Business School, where two professors—respectively Professor Otto Koppen and Dr. Lynn L. Bollinger—discovered they were thinking along the same lines on the need for an entirely new type of aircraft. They felt that a small plane, able to fly very slowly, having a good cruising speed, and able to land on small strips was needed. They collaborated and formed Helio Aircraft Corporation.

Both Germany and Russia are reported to be building STOL fleets. In this country makers appear to be thinking more along the lines of vertical take-off machines and no development of small aircraft on the STOL lines has yet appeared.

Hawker in Australia

The Hawker Siddeley Group are expanding their organisation in Australia. All their activities there (except aircraft) have been placed under the management of a new holding company, Hawker Siddeley Australia Pty. Limited. Mr. W. S. Warner, who was recently elected to the board of Hawker Siddeley Industries and who was chairman of Hawksley Australia Pty. Limited, has been appointed chairman of the new company, and Mr. James S. Samson has been made deputy chairman and managing director.

Commenting on the announcement, Sir Roy Dobson said that this expansion was "evidence of the success of our initial venture in Australian manufacture" and expressed his belief that much of the future efforts of British companies must be devoted to increasing their business in the countries of the Commonwealth. "We have already achieved considerable success in Canada," said Sir Roy, "and we believe that we have a bright future also in Australia and New Zealand." Mr. Warner is currently studying the position in New Zealand.

RCA and Brennan

One of the mightiest of the United States manufacturers of electronic and broadcast equipment, the Radio Corporation of America, has granted a manufacturing and technical aid licence to one of the smallest of British firms in the same industry, John Brennan of Truvu Works, Leslie, Fifeshire. Nor is this accidental, as RCA take considerable pains to elect licensees and would not have even considered an agreement unless they believed that the selected firm could and would successfully develop and promote the sale of their products. Also, that they would uphold the high technical standing of RCA.

John Brennan are a private company employing about 100 people. They are a new concern, only about two years old, which was formed to assemble television tubes. They are now starting to manufacture the electron guns used inside cathode-ray tubes and have moved into a factory of some 60,000 sq. ft. Their products "Truvu" tubes, are distributed nationally for replacement purposes with a twelve-month guarantee, and are competitive in price. Their 17 in tube sells at £10 17*s* 6*d* including purchase tax. This compares with the recently cut price of £17 5*s* 4*d* by one of the big manufacturers, giving only a six months' guarantee. They plan to step up output from the current level of 1,000 a week to 2,000 a week by the end of June, and to increase employment by 50 per cent. Local labour is used, trained by a nucleus of skilled personnel.

Break Down

George Cohen Sons and Company are to dispose of practically the whole of London Transport Executive's fleet of trolleybuses. Their banishment from London's streets follows hard upon the tearing up of the tram lines. Some 1,400 vehicles are involved and disposal is due to begin almost immediately. The conversion to diesel buses is expected to take three years. The first stage, due to come into force from 4 March, will affect three south London routes (696, 698 and 654).

George Cohen's are no sentimentalists and have a long tradition of breaking with the past, however romantic. It was they who scrapped London's old type "general omnibuses," the trams of London, Leeds and Liverpool, and who are currently dismantling the Liverpool overhead railway. While George Cohen are selling or scrapping trolley buses, another member of the 600 Group, G. Beaton and Son Limited, are turning out new tubular seat frames for the new London bus, the "Routemaster."

Automobile Engineering

FORD'S THREE GRACES RESTYLED

New roof panels and exterior trim changes have given Ford Consuls, Zephyrs and Zodiacs a lower line and more glitter, while the interiors have been completely restyled; prices are unchanged. The slimmer roof panel reduces the height by 1½ in, but headroom is unimpaired because softer seat cushions introduced some time ago give a lower seating position. Stainless steel gutters and bolder stainless frames for windscreen and rear windows complete the treatment above the waistline. The standard Consul, like the Consul de Luxe, Zephyr and Zodiac, now has stainless steel instead of painted window frames. New modern tail lamps improve both Consul and Zephyr and the Consul gets the same long rear wings as the Zephyr, which greatly improve the line. Consul de Luxe and Zodiac now have full wheel discs in bright metal and all cars have plated headlamp rims.

Interiors have been glamorised with new slimmer instrument clusters under foam-filled crash pads. Controls are redesigned with decorative knobs and a new twist-release hand brake is grouped on a separate bright metal panel with ashtray, radio (where fitted) and (on de luxe models) a cigarette lighter. The centre of the steering wheel is now faired into a much neater steering column shroud and all models except the standard Consul have half horn rings. All cars have arm rests on all doors, those on the Zodiac being adjustable for height. Twin visors softly padded are standard fittings and for Consul de Luxe and Zodiac a vanity mirror is fitted on the passenger's side. Stylish new easy-to-operate controls working in vertical slides are provided for the powerful 4½ kW heater system. Front doors have new type of safety lock which puts the interior handles out of action and ventilating panes now have a locking anti-theft device. Rubber floor covering on the Consul is improved and side valances are added to the front seating on the Zephyr. A wide choice of upholstery materials and patterns includes hide, rayon and nylon to complete a beauty treatment which will greatly enhance the appeal of all three models.

Since their introduction three years ago, when they were presented as the three graces, 340,000 Consuls, Zephyrs and Zodiacs have been sold; more than half have been exported. Since operations began at Dagenham in 1931 4 million vehicles including tractors and trucks have been built there. Over 3 million have been built since the war.

VAUXHALL VICTOR SERIES 2

Mechanically the Vauxhall Victor Series 2 differs very little from its predecessors. The frontal area of the radiator is increased and the water pump is redesigned. The fan is also enlarged. Service agents will be interested to know that the bonnet now opens 6 in wider than before.

In general appearance the car has become rather more smooth; the grille has been extended right to the sides and the bumper, which is simpler and stronger, sweeps round to the wheel opening. The combined side and flasher assemblies project forward to give side visibility and are made so that the outer half flashes amber while the inner shines white. The body work has been smoothed and in particular the "eyebrow" over the windscreen has gone.

There are now four models: the standard saloon, available in single colours; the super, also in single colour but with blending upholstery; the estate car; and the de luxe which is available in both single colour and duotone and also has individual adjustable front seats and ashtrays. Prices are little changed: the estate car before tax is £15 less at £605; the saloon is £7 more at £505; and the super £10 more at £530. The price of the de luxe, which is an addition to the range, is £565 basic or £908 17*s* with tax.

In the two years since the Victor was introduced the window frames have been increased in size to give better door sealing, the doors have been made stiffer, tools have been modified to improve the fit of body panels and body sealing methods have been redesigned. All cars are now subjected to the most elaborate leak testing routine adopted by any manufacturer. After glazing, but before interior trim is installed, every body structure passes through three consecutive spray booths with a man inside plugging any leaks which appear or marking seals for subsequent rectification.

Paintwork, another subject of complaints on early cars has been improved by a revised underbody dip technique, and a different primer; steps have been taken to ensure more consistent paint thickness. The paint used is now cellulose, not synthetic.

On the engine, fan pulley diameter has been decreased to reduce noise, the exhaust system has been completely redesigned, valve seat cutting technique has been revised, rocker arms are broached to secure quieter operation, the finish of rocker shafts and tappets has been improved and selective assembly is applied to gudgeon pins so that maximum clearance is now 0·0003 in against 0·0007 in. Gear production methods have been changed to eliminate baulking, rear axle tooth form has been modified to reduce noise, axles are now 100 per cent checked to ensure correct pinion loading and improved assembly equipment has been introduced to eliminate oil leakages.

Numerous design changes have been made to the accelerator pedal, front seat backrests (now high), springs in rear seat backrests (now coils), fuel filler, driving mirror and heater as a result of experience in the hands of users.

FIRST LEYLAND FIRE ENGINE WITH UNDERFLOOR DIESEL

The first fire engine made by Leyland's to be driven by an underfloor diesel engine with two-pedal control is for the Manchester City Fire Brigade. It has a very low centre of gravity so that it can corner safely at 50 m.p.h. and the acceleration is such that it can reach 45 m.p.h. in less than 30 seconds with a gross weight of 8 tons 14 cwt. The turning radius is 23 ft. All the pump connections are at the front and there is also a control panel there.

The Firemaster chassis has a straight frame with a six cylinder 0·600 diesel engine mounted at the centre below frame level. This unit is generally similar to that fitted in the Leyland Worldmaster bus, except that it has a hydraulic all-speed governor and an inlet manifold with an intake at the rear through a paper-element air cleaner. For roadwork the engine develops 150 h.p. at 2,200 r.p.m., but for pumping purposes it is governed at 1,500 r.p.m. to provide a pump speed of 3,000 r.p.m. The main pump will deliver 1,000 gallons per minute. A feature of the engine cooling system, which is pressurised to 4 lb per sq. in, is that the closed circuit system is still maintained during pumping operations and no external supplementary cooling water supply is required.

Drive from the engine is taken through an 18 in diameter fluid coupling to a Leyland Pneumo-Cyclic four speed semi-automatic gearbox which has an electro-pneumatic change speed lever mounted on the steering column. A pulley on the drive between the fluid coupling and the gearbox drives a dynamo, mounted above the gearbox, and an eight-bladed radiator fan through a right-angle box. The radiator is mounted longitudinally alongside the chassis frame just in front of the rear nearside wheels. A short tubular propeller shaft carries the drive to a Leyland-designed axle incorporating an Eaton two-speed driving head equipped with an electric gear change.

At the front of the engine a shaft taken from the crankshaft drives a specially-designed power take-off with a 1 to 2 step-up ratio. The power take-off drives the main fire pump and a first aid pump, both mounted at the front of the chassis. An air-operated clutch transmits the drive to the gears by means of dog clutches. The air-operating cylinder for the clutch has an interlocking mechanism so that the pumps cannot be run when the road wheels are driving.

The Firemaster fire pump is diesel driven and has all pump connections at the front.

Special Article

SLOT MACHINE SELLING

Automatic Vending as a Reflection of the Times

No section of the light engineering industry has risen more spectacularly as a phoenix from its ashes than the manufacture of vending machines. Between 1942 and 1953 slot machines were completely out of use in this country. Today there are probably 50,000 in use and their number is fast increasing. This expansion has all taken place in the last five years.

It is not only that the old machines were worn out or had fallen into disrepair. The vending machine of today has to justify its existence in a more exacting technical and economic environment than its predecessor of 20 years ago. In one sense the industry has triumphed over adversity since times of inflation are not ideal for the slot machine industry. When prices change and the value of money is reduced in a period of inflation, machines may have to be adapted fairly frequently to take different coins and give different amounts of change. In theory the slot machine industry should flourish in times of stable prices and if this is so, great as the progress has been in the last five years, it may be relatively greater in the next decade if inflation can be effectively contained.

The come-back of the slot machine owes a great deal to the change in shopping habits which is developing in this country. The importance of display and good packaging has for many years been one of the main ingredients in the success of the multiple shops. Of recent years the development of self-service stores and supermarkets has further catered for a public which wishes increasingly to buy standardised, well packaged goods (and this means both food and clothing) with decreasing attention to discriminating buying and the quality of services offered in shops. This kind of buying finds its logical development in the slot machine.

Not all big manufacturers of standard products have taken to the vending machine. At one extreme the British Automatic Company Limited, probably the largest operating company, have replaced its 30,000 pre-war machines gradually over the last five years. On the other hand, the Imperial Tobacco Company Limited were slow to go back to these machines and their decision to do so is not much more than two years old.

The big development since 1953 has been the increasing number of more complex machines which have been introduced. Many of these owe their inspiration to the United States and some are manufactured in this country under licence from the United States companies. A high proportion of the new machines are built round the 6*d* and the 2*s* piece although there are some which can still take 1*d* and others as much as 4*s*. Increased complexity has meant that the initial outlay on machines and their servicing costs are very much higher than they used to be, and of course many have had to be modified fairly quickly in the last decade to cope with price changes. The seriousness of this problem of changing prices can be seen from the experience of the London Transport Executive. Their ticket machines were installed to last 15 to 20 years but they have been difficult to adapt to rising fare charges. Many of the 465 giving change have had to be blocked up because they can only operate on the exact fare. Nearly half of the 275 that do not give change have had to be taken out of service as they were designed to take not less than 3*d*.

The type of slot machine which most people have been familiar with for many years is the one with a column of packages in a single stack with a gravity feed. More elaborate versions hold four to six columns but operate on the same principle, and it is this type of machine which has been installed on railway and Underground stations by the British Automatic Company Limited for the sale of sweets and chocolate. The range of products has been extended of recent years to include such packaged goods as cigarettes, films and sanitary towels. In 1956 Ilford began selling films in four-column machines manufactured by Hall Telephone Accessories Limited from points of sale outside shops stocking photographic apparatus and chemists' goods.

Among cigarette machines there has been a move towards greater complexity. The largest British manufacturers of cigarette machines are probably Brecknell, Dolman and Rogers Limited, followed by Master Vending Machines Company Limited, but there are a number of small concerns making special types of machines. On the cigarette side one of the biggest operators (as distinct from machine makers) is Automat Machine Sales Limited, who have machines ranging from a single-column model capable of selling 25 packets of ten to a double-decker 17-column machine capable of taking 243 packets of ten and 184 packets of 20. These machines give change and are simple to adjust for price changes. Their price varied from £43 10*s* to £390 in 1957, depending on the degree of complexity. In 1957, this operating company introduced a book-vending machine for Penguin books. The machines for Penguin books have four columns with one 2*s* 6*d* coin slot. This company only started operations in 1955 and by the end of last year had imported as many as 11,000 machines from Denmark.

Another maker of gravity slot machines is the Self-Service Company Limited with models selling confectionery, nuts and hygiene articles. The machines are free on loan with free servicing, the site owner buying supplies from the company and retaining all takings.

AUTOMATIC SHOP

Some machines cater for articles of irregular shape such as groceries. These usually operate on a conveyor belt or revolving drum principle. Brecknell, Dolman and Rogers, for example, make the Vendol "automatic shop" which works on the revolving drum principle. It can hold up to 200 different articles to sell at 2*s*, 1*s* and 6*d* each and costs about £350. Automat Machine Sales have a self-filling machine called the "ever open shop" in which a segmented rotating tray automatically transfers new goods to the front of the compartments to sell. The trays are of different sizes with two to eight segments to suit articles of different shapes and sizes. The result is a range of machines holding anything from 64 to 384 articles and ranging in price from £177 to £700.

Another type of vending machine which in fact operates as a shop window is the Vitrinomat made by Ditchburn Vending Machines Limited. Here the display cabinet of the machine is a shop window with rows of drawers along the bottom with a coin slot at the side. A retailer as large as the Express Dairy Company Limited has become interested in this idea. These machines, which are not necessarily on the conveyor belt or revolving drum principle, cost anything from £300 to £1,000 each.

Of recent years automatic machines for selling milk, Coca-Cola and other soft drinks as well as hot beverages have been introduced. Hall Telephone Accessories Limited started the manufacture of a bottled-drink machine eight years ago, and by 1956 is reported to have supplied 2,000 of these to Coca-Cola. The Coca-Cola Company installed a cold drink vending machine in the London factory of Firestone Rubber Company Limited in March, 1954. By September, 1956, there were 200 in factories and it was noticeable that sales were higher in engineering, glass works and foundries where temperatures are high. The bottled drink vendor costs about £100. It has a capacity of 104 bottles of which 16 must be in the "cooler" so refilling is necessary after 88 bottles have been sold. The Coca-Cola Company employs salesmen to visit its installations daily but arrangements can also be made to supply cases of drinks direct.

If cardboard cups are used instead of bottles, twice as many drinks can be obtained from a vendor without replenishing it. Some years ago Chadburns Limited, makers of shipping telegraphic equipment, introduced a cup model and full production of 15 machines a week was due to start in 1957.

Pepsi-Cola Bottling Company supply two types of machine, one for bottles and one for cups. The beverage is pre-mixed in stainless steel containers and the machines cost about £320 each. Rental terms are also available to factories and Pepsi-Cola in these cases maintain the machines.

Coolers and Vendors Limited, which is controlled by Camp Bird Limited, sell machines for both cold and hot drinks. One bottle vendor which serves ice-cold soft drinks takes up to 93 of almost any type of bottle or can weighing from 6 to 8 oz and incorporates a Frigidaire refrigeration unit. It costs £185.

Joseph Sankey and Company Limited make in this country the Vendo milk vending machine under licence from the Vendo Company of Kansas City, USA. The machine holds

210 half-pint cartons of refrigerated milk and these are dispensed at a temperature of 35° to 40° when a coin is inserted. There is a selection of soft drinks as well as flavoured milk. The same company in this country is reported to be developing a tea machine. Another company, Farrow and Jackson Limited, have produced a vending machine which dispenses milk and non-carbonated soft drinks in cartons. This machine can give change for 6*d* or 1*s*.

W. M. Still and Sons Limited make coffee and hot chocolate machines under United States licence as a part of their range of catering equipment. Their machines have a capacity of 150 cups and are based on a machine developed in America. The same company has brought out a tea vending machine with similar capacity at a price of £350 but the varying requirements of the strength and sweetening of the tea are likely to make it a fairly slow and hazardous business to establish a machine of this kind which can pander to the public taste and yet remain mechanically reliable.

Coffee and tea machines have been made by other people and put on the market in the last few years. Among these are Coolers and Vendors Limited (under licence from Mills Industries of Detroit) and the Supreme Automatic Vending Company Limited. There may be a big market in factories and offices for machines of this kind. (One recalls the story at Dagenham that Ford would have piped hot tea through the works if they had known the tea breaks were going to take as much off production time as proved to be the case when that factory was built.) It seems likely, however, that they will have a good many teething troubles before they are both accepted and profitable. One of the problems which arises in establishing this kind of slot machine is the habit which many organisations have of subsidising tea and coffee. If these machines are to have a widespread market there will have to be some rebate system operated in factories which charge employees less than the price of a cup of tea or coffee from a vending machine on, say, a railway station.

A certain amount of progress having been made in selling hot and cold drinks from machines, it is not surprising that organisations have come into existence to develop the idea of the automatic vending of snacks. Some of these are fairly simple. Ice-cream dispensers have been installed in a number of factories, the principal manufacturer of these machines being Ice-Matic Limited. This company's machines hold 240 bars of ice-cream and cost £385. In winter the refrigeration unit can be switched off and the machine can be turned over to selling confectionery. Confectionery is indeed the main type of food offered in snack form. At the Nestle's factory at Hayes automatic machines have been used to supplement canteen facilities by providing sandwiches, cakes, soft drinks and the like.

HOT MEALS

Sandwiches and hot canned foods have been sold in United States factories by means of slot machines for many years and complete hot meals are available, although the pace of development is slowed down by the public health laws which vary from State to State. In the United States the future of the vending machine industry is considered to be with sales of a wider variety of cooked and uncooked foods rather than with packaged non-food items. In November, 1957, it was stated at the annual convention of the United States National Automatic Merchandising Association that one out of five American factories used coin vending machines exclusively to feed employees, although eight out of ten had installed them to provide refreshments.

In this country Vendepac Limited install and operate machines in factories to sell biscuits, sandwiches, other snacks and hot and cold drinks. A special machine for sandwiches with 40 compartments was put on the market at the end of 1957 by Griffiths (Caterers) Limited for £35. Both Sankeys and Automat Machine Sales have been reported to be interested in selling hot canned food vending machines or hot meal machines. Selling these types of machine in this country may require a good deal of ingenuity and boldness, for most potential customers are conservative about food and some managements are averse to having vending machines in their factories at all—in some cases perhaps because they have spent large sums of money on canteen equipment.

This somewhat conservative attitude may be contrasted with the announcement in July, 1956, in the United States that completely automatic food stores would be installed in 12 areas of the Union under the auspices of the Independent Grocers' Alliance. The stores operate by means of a conveyor belt and electronic system. Food items are obtained by putting a large metal key in the display cases. At each insertion the amount of each item is electronically recorded inside the key which is presented for payment at the check-out point. This device has been developed by the Independent Grocers in America to win customers from the big grocery chains.

The evidence available suggests that this country is lagging behind in the slot machine business. The United States, Scandinavia (notably Denmark), Germany and even France are expanding the use of vending machines at a pace which compares favourably with the United Kingdom performance. In the United States it was estimated that last year 20 per cent of all soft drinks and 16 per cent of all cigarettes were bought from slot machines. The largest United States company making and operating vending machines is the Automatic Canteen Company which amalgamated in 1955 with the Rowe Manufacturing Company. The second largest is Continental Industries of Westbury, NJ, which was the outcome of an amalgamation between the National Vending Corporation and Continental Car-Na-Var Corporation in 1956. The largest manufacturer of equipment is considered to be the Vendo Company which acquired the Vendorlator Manufacturing Company in 1956.

This field of light engineering, even in this country, has attracted already a number of concerns not all of which are traditionally connected with vending machines. It is just possible that at the present time, the competition is growing slightly more rapidly than the opportunities. So far as these last are concerned, much now depends on how quickly British conservatism in food buying habits can be broken down.

Atomic Review

Activity in a Cage

A NUCLEAR reactor is a three-dimensional lattice holding captive an activity, which, but for the lattice, would die. Many kinds of cage are possible and some are described below.

Nuclear Superheated Reactor

The USAEC has filed with the Joint Committee on Atomic Energy of the Congress the basis for an amendment to the existing agreement between the Commission and the Northern States Power Company, Minneapolis, Minnesota. The proposed amendment provides for Commission research and development support for a nuclear superheater to be incorporated in the 66 MW (electrical) reactor plant to be constructed by Northern States at Sioux Falls, South Dakota, under the Commission's Power Demonstration Reactor Programme. The original plant concept was a boiling-water reactor with a separate conventional superheater. In the proposed concept this superheater would be eliminated. The reactor under the new proposal would consist of a two-section core in which saturated steam, formed in the outer section, flows through the inner section where it is converted to superheated steam. The higher temperature of superheated steam, whether generated from conventional or nuclear sources, would result in increased plant efficiency.

The Commission signed the original contract with Northern States in November, 1957. This contract provides that Northern States will build at its own expense and will operate for five years a nuclear power plant of an advanced boiling water type, incorporating large-volume controlled circulation of the water coolant-moderator. The reactor will be fuelled with slightly enriched uranium. The nuclear superheater portion of the core will use highly enriched uranium. Construction of the plant is scheduled for completion by 30 June, 1962. This schedule is not expected to be affected by incorporation of the nuclear superheater. The Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, is the principal subcontractor for the performance of research and development, fabrication, and construction of the reactor.

Boiler-Superheater Reactor

A reactor design in which heat is removed by water and steam in independent cooling channels has been described by Mr. T. P. Heckman, of the Chicago Operations Office, USAEC, in a recent article in *Nucleonics*. The arrangement of the proposed design is shown in the illustration on page 268. Moderator-coolant water flows down the centre of tubular elements and out from the bottom of the reactor; steam flows upwards through the spaces between the elements where it is dried and superheated before leaving the top of the reactor. This arrangement increases core size, mechanical and fabrication problems, and hence cost; but, in compensation, certain advantages over conventional boiling-water reactors are claimed: (1) low rate of moderator circulation should give savings in pumps, valves and piping; (2) dry or superheated steam should afford economies in steam separators and in turbine design; (3) reactivity control would be independent of the steam-void fraction; but control is directly related to the steam generation rate through the temperature coefficient; and (4) the design is said to be insensitive to distortion of fuel-element dimensions.

As the water passes down inside the tubes some will pass through holes in the couplers in each tube train to wet the outside surface of the fuel-element tubes. Steam formed on the outside surface of the tubes plus the steam that separates at the bottom orifice of each tube will pass upward and out of the reactor. Rough calculations for a 1,000 MW (thermal) reactor indicate that a 11·5 ft by 11·5 ft core would be critical. Control would be by positive displacement of heavy water and mercury through a system of concentric tubes.

Nuclear Superheating

It is reported that the experimental boiling reactor Borax-4 is being converted into a 40 MW (thermal) reactor known as Borax-5, which will be used to test fuel samples and other materials for nuclear superheaters.

PWR of 330 MW Capacity

Westinghouse have announced that they are prepared to develop, design and manufacture the equipment for a 330 MW nuclear power plant using an advanced form of pressurised-water reactor. The plant would probably be competitive in high-cost areas of the United States with power stations burning fossil fuels.

PWR of 5 MW Capacity

Westinghouse Electric Corporation are to build a 5 MW pressurised-water reactor plant for the General Public Utilities system for use at a power station now in operation near Saxton,

Continuing Atomic Review

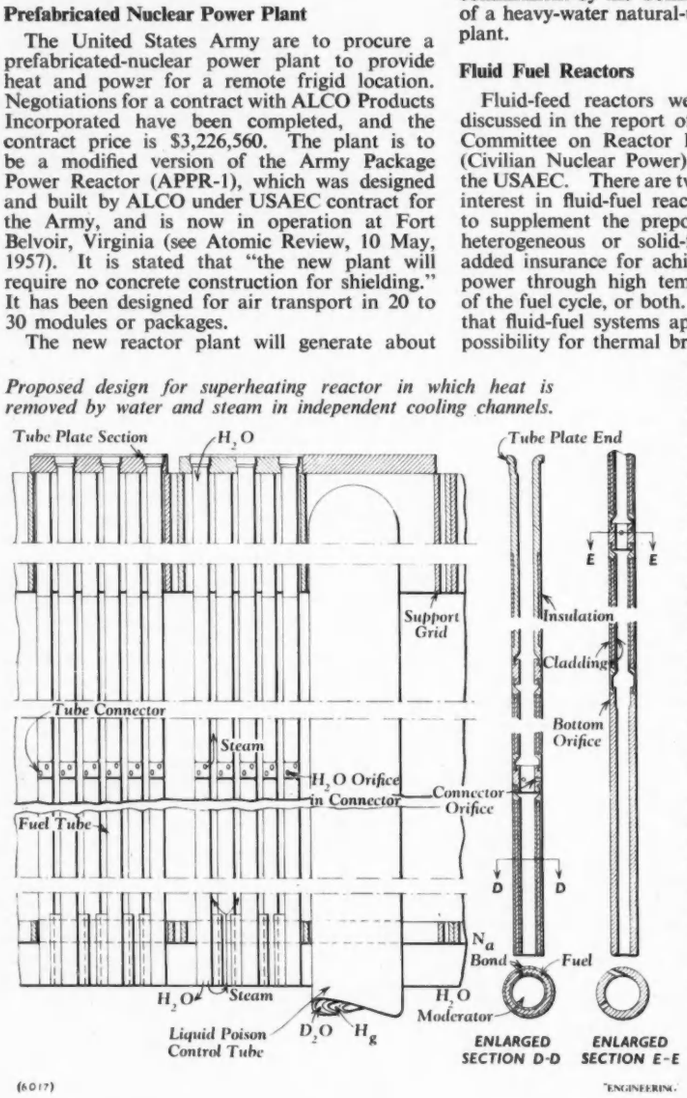
Pennsylvania, where it will supply steam to an existing turbogenerator.

Prefabricated Nuclear Power Plant

The United States Army are to procure a prefabricated-nuclear power plant to provide heat and power for a remote frigid location. Negotiations for a contract with ALCO Products Incorporated have been completed, and the contract price is $3,226,560. The plant is to be a modified version of the Army Package Power Reactor (APPR-1), which was designed and built by ALCO under USAEC contract for the Army, and is now in operation at Fort Belvoir, Virginia (see Atomic Review, 10 May, 1957). It is stated that "the new plant will require no concrete construction for shielding." It has been designed for air transport in 20 to 30 modules or packages.

The new reactor plant will generate about 1,500 kW net electricity for heat and power, plus about 1,000 lb. of steam (or 1 million Btu) per hour. The steam can be used for heating barracks, melting ice for water supply, or on research and development projects. In contrast to the APPR-1, which uses water from the Potamac River, this package plant will feature a condenser cooling system using air and ethylene glycol. Fuel for the reactor will be essentially the same as that used in the Belvoir plant—uranium oxide, clad with stainless steel. The uranium in the core weighs about 40 lb and will provide operating fuel for a period ranging from one to two years. About 10 lb of uranium will be consumed between periods of refuelling.

Proposed design for superheating reactor in which heat is removed by water and steam in independent cooling channels.



Heavy-Water Reactor for USA

The US Atomic Energy Commission has invited United States architect-engineering firms to submit proposals for performance of studies on a heavy-water-moderated power reactor capable of operating on natural uranium fuel. The design studies to be made on a cost-plus-fixed-fee basis will supplement developmental work already in progress.

The Commission, which had previously indicated the belief that this is one type of reactor desirable for the development of economic nuclear power, has determined that it can best be developed by the continuation of developmental work conducted by E. I. du Pont de Nemours and Company since 1956, and by the performance of certain design work at Government expense. The invitation for proposals and the continuation of developmental work do not, however, imply commitment by the Commission to construction of a heavy-water natural-uranium power reactor plant.

Fluid Fuel Reactors

Fluid-feed reactors were among the topics discussed in the report of the ad hoc Advisory Committee on Reactor Policies and Programs (Civilian Nuclear Power) published recently by the USAEC. There are two principal reasons for interest in fluid-fuel reactors. One of these is to supplement the preponderance of work on heterogeneous or solid-fuel reactors to give added insurance for achieving low-cost nuclear power through high temperature or simplicity of the fuel cycle, or both. The second reason is that fluid-fuel systems appear to offer the only possibility for thermal breeding on the thorium to uranium 233 fuel cycle with an acceptable doubling time—say ten years or less. Uncertainties in the value of *eta* (the number of neutrons emitted per neutron absorbed) make it impossible to give positive assurance that breeding on this cycle can, in fact, be achieved. The committee strongly recommends that urgent effort be devoted to measurements of *eta* for uranium 233 by various laboratories and by various methods.

Until better knowledge of *eta* is obtained, work on thermal breeders should be held to a minimum. However, development of a thermal breeder reactor, if shown to be feasible, should be included as part of the overall programme at approximately the present level of effort on the aqueous homogeneous project. Based on present information, breeding with the thorium to uranium 233 cycle is uncertain for aqueous homogeneous reactors, even more uncertain for liquid metal fuel reactors, and not possible for molten-salt reactors.

Of the three fluid-fuel reactor types, the aqueous homogeneous is of interest as a breeder and because of its simplified fuel cycle, the molten salt is of interest because of high-temperature operation and simplified fuel cycle, and the liquid bismuth because it might incorporate all three advantages. All three types, particularly the liquid bismuth, present many difficult development problems. For example, it is probable that for successful breeding in the aqueous homogeneous or in the liquid bismuth reactors, a slurry will have to be used at least in a blanket, and the development of adequate slurry technology is a very difficult task.

The three fluid-feed systems should be evaluated first as to promise for producing low-cost nuclear power and not more than one project supported on the basis of that objective. When additional information on the value of *eta* for uranium 233 is available, the situation with respect to thermal breeding should be re-examined, with a view toward increasing support. The committee see no present basis for the construction of fluid-fuel reactors of any of the three types.

Design and Engineering Studies of Three Reactors

The US Atomic Energy Commission has invited qualified United States firms to submit proposals for preliminary design and engineering studies and cost estimates for nuclear power plants employing three tested reactor concepts. The purpose of the studies is to discover what reactor concept would constitute the most economical nuclear power station, taking into consideration the present status of nuclear engineering, future power requirements, the characteristics of available generating equipment and the possibility of starting construction by a private or public organisation of the first unit of each plant in the United States or abroad by July, 1960. The three reactor concepts selected by the Commission for study are the boiling water reactor, the pressurised water reactor, and the organic cooled reactor.

Further Details of Daniels-Boyd

The Daniels-Boyd Nuclear Steam Generator, described in Atomic Review last 26 December, is a projected Canadian high-temperature gas-cooled reactor with a core comprising a heterogeneous mixture of graphite moderator and enriched uranium monocarbide fuel (see Atomic Review noted above). More details are given by Mr. Winnett Boyd and Mr. Laurent Amyot, formerly of the C. D. Howe Company engaged on the Daniels-Boyd project, in articles in *Modern Power and Engineering*. Maximum fuel temperatures of 2,800° F (1,540° C) are envisaged and a fuel enriched to somewhat in excess of 0·75 per cent uranium 235. To give increased burnup, bi-directional fuelling is proposed (see Atomic Review last 12 September), and a burnup of 10,000 MW days per tonne with 1 per cent

TABLE.—*Some Properties of Reactor Materials (at Room Temperatures)*

Material	Use	Density, gm per cc	Melting point, °C	Boiling point, °C	Specific heat	Thermal conductivity, gm cals per cm per sec per °C	Thermal neutron absorption cross section (Barns)
Uranium	Fuel	18·9	1,132	3,900	0·028	0·060	7·68 (natural U)
Uranium dioxide	Fuel	10·9	2,875	—	—	—	7·68 (natural U)
Zirconium	Canning, alloy with U	6·4	1,845	—	0·069	0·057	0·18
Beryllium	Canning, moderator, reflector	1·85	1,315	2,970	0·42	0·36	0·01
Heavy water D_2O	Moderator, reflector	1·1	0	101	1·01	—	0·00092
Helium	Coolant	$0·166 \times 10^{-3}$	−271	−271	1·25	$3·32 \times 10^{-4}$	0·007
Sodium	Coolant	0·97	97	883	0·33	0·205	0·49
Hafnium	Control absorber	13·3	2,130	—	0·035	—	115
Lead	Shielding, coolant	11·35	327	1,737	0·39	0·039	0·17
Water	Shielding, coolant, moderator	1·0	0	100	1·0	0·0013	0·66
Aluminium	Canning	2·7	660	2,450	0·222	0·53	0·22
Bismuth	Coolant	9·75	271	1,477	0·0345	0·037 at 600° C	0·032
Stainless steel	Structural, possible canning	7·92	1,400	—	0·12	0·037	2·5

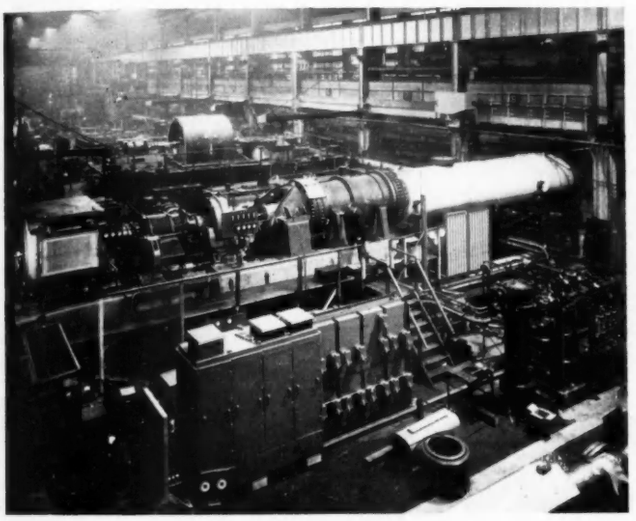
initial enrichment is anticipated. To facilitate chemical processing the number of enriched elements is to be reduced by using a square lattice of natural uranium monocarbide elements superimposed on a square lattice of enriched slugs. It appears that when the quantity of enriched slugs exceeds 10 per cent, the loss in nuclear efficiency due to lumping the enrichment is not excessive.

The helium coolant is designed to flow upwards through the reactor, being raised from its minimum temperature of 450° F (230° C) to a maximum of 1,250° F (680° C). The steam conditions at the throttle would be 1,050° F and 2,400 lb per sq. in, though a dual-pressure cycle, as at Calder Hall, is envisaged with low-pressure steam conditions of 950° F and 600 lb per sq. in. The proportion of high to low pressure steam is to be 1·81 : 1; but some low-pressure steam is used to drive the turbo-alternator supplying the gas blowers and the steam reaching the main turbogenerators is in the proportion 2 : 1.

Advanced Gas-Cooled Reactor Power Stations

It is expected that from about 1965 onwards the reactors for British nuclear stations will be based on the AGR using uranium oxide fuel and beryllium instead of magnesium cans. This will permit higher operating temperatures and heat ratings and consequently will lead to greater efficiencies than can be achieved in the reactors currently being built for the electricity authorities. The levels of radiation inside the reactors will be considerably higher. Two broad categories of problems are raised by these more arduous conditions: those of reactor physics and those of reactor materials.

One of the gas circulators for the Berkeley nuclear power station, showing the ducting for closed-circuit air testing.



The most important material problem is to develop fuel elements which can withstand high burnup under the exacting conditions of high temperature and high flux and the main purpose of the AGR prototype is to test various types of fuel under full reactor conditions—it is essentially a fuel element development reactor. For this reason it has been designed to operate at 100 MW of heat, generating 30 MW of electricity, and it will be most important for it to run at high power for prolonged periods. The reactor physics problems concern the behaviour of neutrons within the reactor. The high radiation levels necessary in AGR for fuel testing and power production prevent the physicist from gaining access to the parts of the reactor which need most careful study. Sensitive techniques, however, are available with which it will be possible to carry out the necessary measurements at low radiation levels in HERO. The importance of highly refined reactor physics work lies in the very competitive nature of present day reactor design, which demands extremely careful optimisation of reactor cores. With the large programme of nuclear power installation in the United Kingdom, even a slight improvement in efficiency brings appreciable returns. In addition there are the problems of the kinetics and stability of highly rated reactors. AGR fuel is intended to remain in the reactor for a long time, building up very substantial amounts of plutonium. The reactivity of such a system is strongly dependent both on the fuel and moderator temperatures and on the isotopic content of the fuel and careful study is therefore needed of the stability and control of such reactors.

Temperature Coefficient

Speaking in Tokyo recently on "The British Nuclear Power Programme," Sir John Cockcroft discussed certain problems of gas-cooled reactor kinetics. No automatic control system is installed in the Calder Hall reactors but the circuit has proved to be remarkably stable. The temperature of the fuel elements stays constant to $\pm 1°$ C and there is a similar stability of power level. The reactor kinetics are largely determined by the way the reactivity—or neutron surplus—changes with temperature. When the reactor starts with a new charge of fuel the reactivity decreases with increase of fuel element temperature and also with increase of moderator temperature. The reactor is said to have a negative temperature coefficient so a temperature change tends automatically to be compensated. With increased irradiation of the uranium fuel, the plutonium content increases and this changes the picture. An increase of temperature of the fuel still leads to a decrease of reactivity but an increase of temperature of the moderator leads to an *increase* of reactivity. When the fuel is irradiated in a complete charge to an average level of almost 450 MW days per tonne, the moderator temperature coefficient is $4·7\ 10^{-5}$ k per °C at the operating temperature.

In the Electricity Board reactors the value of the moderator temperature coefficient and its effects, are sensitive to the details of design and to the fuel cycle adopted. In a typical case, using a graded fuel cycle to achieve 3,000 MWD per tonne irradiation, it is estimated that the coefficient will be almost 15×10^{-5} k per °C and that this will lead to a doubling time, for a power disturbance, of about two minutes. Thus a change of thermal power level from 200 to 201 MW would lead two minutes later to a power level of 202 MW and two minutes later again to 204 MW if no compensating action of the control rods took place. These power level changes are still slow compared with the time that the operator takes to adjust the power level.

Properties of Reactor Materials

The table on page 268 is taken from an article, "Nuclear Power Plants—An Outline of the Experimental Programme Necessary to Support a Nuclear Power Project," by Mr. J. Edwards of the Naval Section, AERE, published in the *Journal of the Royal Naval Scientific Service*.

Notes and News

Sites for Nuclear Power Stations Investigated

The Central Electricity Generating Board propose to carry out detailed investigations of two areas on the central south coast to see how far they offer the necessary facilities for nuclear power stations. These are at Earnley in West Sussex and at Hamstead on the Isle of Wight. There is an urgent need to explore ways of expanding power generating capacity in this area to help meet the constantly growing demand for electricity both in the coastal towns on the southern seaboard and in the counties inland. The investigations, like those carried out in other areas, will include ground surveys, trial borings and hydrographic surveys and will take several months to complete.

Japan Negotiates with GEC Exclusively

The Japan Atomic Power Company have opened exclusive negotiations with the General Electric Company Limited for the supply of an 150 MW nuclear power station to be built at Tokai Mura, 65 miles north east of Tokyo. The plant, which should come into operation in mid-1963, will include a single reactor of the kind being built by GEC and Simon-Carves at Hunterston, though with certain modifications in structure and control to allow for Japanese conditions. Letters of intent are anticipated next month and the entire contract is expected to amount to about £30 million.

Gas Circulator for Berkeley

The accompanying illustration shows one of the 164,000 h.p. motor-driven gas circulators for the Berkeley nuclear power station erected for test in the British Thomson-Houston Company's works in Rugby. The ducting for closed circuit air testing can be seen.

West German Power Reactor Contract

An order for a 100 MW natural-uranium gas-cooled heavy-water moderated power reactor has been placed by a Bavarian company, in which several utilities, the Bavarian State and Farbwerke Hoechst have joint interests, with the Siemens group. For the background to this order see Atomic Review last 2 January.

East German Power Reactor

Construction of the first East German power reactor, of pressurised-water design, is reported to be making substantial progress near Neu-Globsow, Kreis Gransee. Initially there is to be a 70 MW (electrical) unit, which will later be supplemented with another.

Japanese Power Project

British and American designs are being considered for a 210 MW power reactor, which the Kyushu Electric Power Company propose to operate by 1964.

First Indian Power Reactor

Dr. H. J. Bhabha, chairman of the Indian Atomic Energy Commission, is reported to have told delegates to the Indian Science Congress last 23 January that preliminary work had started on the construction of a nuclear power station in India. The 20 MW prototype reactor might be completed within the next five years. His other remarks suggest that a heavy-water moderator may be used and that a thorium breeding blanket may be incorporated. As far as possible, design and construction would be carried out in India and fuel requirements would be met from indigenous resources.

Atomic Energy Professors Tour Latin America

Arrangements have been made with the agreement of the Foreign Office, the Board of Trade and the nuclear energy consortia for Professor W. Murgatroyd, professor of nuclear engineering at Queen Mary College, London, and Professor J. M. Kay, professor of nuclear power at Imperial College, London, to carry out lecture tours in eight Latin American countries under the sponsorship of the British Council. They will lecture to engineers and scientists on British nuclear development and aims and the need for future co-operation with the United Kingdom. Professor Murgatroyd will visit Venezuela, Colombia, Peru and Mexico from 30 March to 29 April; and Professor Kay Chile, Argentina, Uruguay and Brazil from 23 March to 29 April.

USAEC Resignation

Dr. Willard F. Libby is understood to have resigned from the United States Atomic Energy Commission, after completing 3 of the 5 years which constitutes a term of office, in order to return to teaching and research. He was the only member to have a scientific background.

The Human Element

The Pomp of Power

Winged lion, red dragon and griffin are all together in new bearings selected for the Central Electricity Generating Board. This lion and dragon are "supporters" for a simple but striking shield. They allude to England and Wales respectively, the countries over which the Generating Board's responsibilities extend. The shield consists of two bars placed in a zig-zag horizontally across the shield—heraldically speaking "Paly gules and or two bars dencetty the upper per pale sable and argent the lower per pale argent and sable." For the badge "a male griffin segreant gules armed langued and rayed or behind the head a sun in splendour gold." The usual depiction of the griffin—"bursting with rays," suggests energy, which, states the announcement, "makes it appropriate to the Generating Board."

The motto is from "Dryden's poem "Absalom and Achitophel": "all empire is no more than power in trust," hence "Power in Trust" presumably meaning electrical power held in trust for this sceptic isle by a most energetic board. It is all rather fine and colourful, with red predominating—one hopes not prophetically.

For Them Who Can Read

Despite the horrific pictures painted in some quarters about the distracting power in turn of picture magazines, radio and television, the demand for reading material in libraries has been increasing steadily for many years. This may be partly because more people want to read or because fewer people can afford to buy books. A White Paper was issued last week called *The Structure of the Public Library Service in England and Wales* (Cmd. 660, price 3*s* 6*d*). This report foresees a continuing increase in the demand for books and is concerned to set certain standards in capital outlay, running expenses and quality of service south of the Tweed.

The controversial side of the White Paper is concerned with the proposals for having some form of central control from Whitehall by the Ministry of Education in the interests of maintaining standards and ensuring a uniform standard of service throughout the country. Where a certain level of annual expenditure on books is not achieved by a local authority the report suggests it should lose its status as a library authority. This will touch off an old problem, namely, how far efficiency standards and subsidies from London should be allowed to override local pride and responsibility. This controversial issue will lose no edge since it is likely to be argued out to a large extent in terms of Welsh rural areas.

Wagging Tongues

The employees of Vauxhall have been admonished and warned, in a 12-page booklet entitled *Careless Talk Costs Jobs*—a little too reminiscent, perhaps, of nastier things and darker times, but understandable. It strikes at the root of the average man's pride—his work—and at one of his most cherished rights—talking shop. Chance remarks in club or pub, barber's shop or garage, "might be overheard by someone who will relay the information, often embellished." Also, workers are advised "to be careful what they tell their wives," to keep all blueprints, letters and papers out of sight, and to be discreet when using the telephone.

The main fear would appear to be not so much the spreading of secrets to competitors—though this is stated—but the fact that reports about new models have often caused customers to delay their purchase, causing a slump in sales and endangering employment. It is salutory for workers to be told that tooling up for a new model costs some £4 million or more, but they may find it hard to understand how competitors could benefit from the news that a new model is projected, and that it will have wings or be propelled by a rocket. Much more dangerous is the rumour that something new is coming out, which as the booklet points out, can become "forest fire" rumour overnight. This could cost jobs, and has done so.

By Any Other Name

The decision of the Institution of Electrical Engineers to change the name of the Radio and Telecommunication Section to the Electronics and Communications Section has behind it an issue of importance so far as engineering as a discipline is concerned. The institution rightly draws attention to the unreal distinction which may be drawn between an electrical engineer and an electronics engineer and to the need to maintain a single forum of discussion for the development of electrical engineering science.

There is a tendency today for different intellectual disciplines to splinter off in trying to assert themselves. Academic disciplines become confused with bodies of knowledge which have no claim by rights to a discipline of their own. Fashionable techniques for solving current problems become enshrined in university chairs. Only those who are concerned mainly with fundamental research and the rethinking from time to time of basic issues in a particular discipline can fully appreciate the value of striving for the unity of knowledge.

There are signs that progress is being made in this direction. Engineering is getting closer, for example, to medicine. Specialisation is necessary, but safeguards must be built in to ensure that this wholly desirable trend does not become a sophisticated form of empire building.

Exact Day Labour Denied

It was not to be expected that the Industrial Disputes Tribunal would bring its activities to a close with the award of a 40 hour week to the engineering unions. The issue is far too complicated in its effects for a body such as this.

Everyone knows that if one union gets some sort of negotiated approval for the 40 hour week it will be only a question of time before they all get it—if they want it. This fact alone is likely to make it difficult to achieve. From the unions' point of view there are attractions especially in a time of recession in trying to reduce working hours. It fits into the need to spread work so far as possible over as many men as possible; such is the union point of view. It also can be used instead of a wage demand when times are difficult, costs are stable and profit margins are falling.

It is almost certain now that the summer conferences of the engineering unions will favour putting in wage claims, and since this may well coincide with a marked improvement in industrial conditions little more may be heard about the 40 hour week for some time to come.

Cross Breeding with the Alien

Hospitals are not the kind of organisation to excite the interest of the engineer unless he is unfortunate to have dealings with them in their professional capacity. Nevertheless a recent report of the Acton Trust, *Creative Leadership in a State Service—a General Survey* (The Acton Trust, price 4*s*) makes a basic point which all technical people who aspire to top positions should bear in mind. Sir George Schuster, chairman of the trust, points out that the hospital administration has something to learn in its search for efficiency from army organisation and from industry. He is well qualified to say so for he has had a distinguished career in the Indian Civil Service and has held responsible positions in industry. He is in fact pleading for a cross-fertilisation of ideas between different forms of organisation.

The argument goes beyond the need to get cross-fertilisation among administrators. It applies equally well in many contexts between technical people and between technical people and the administrators. Specialised knowledge and experience in a given field are not to be underestimated but there is a need in all large organisations to get departmental heads to work together on common problems. Trained minds from different disciplines need to be brought together to solve common problems affecting the organisation as a whole in a spirit of constructive common purpose and not as a form of inter-departmental horse-trading. The more specialists that are trained the greater will that need become.

Continuous Creation

It is popularly supposed that human powers, and particularly creative ability, diminish with age. We continue to believe this even when we are surrounded by living examples of persistent vigour and imagination. Last week a septuagenarian, eminent as engineer, scientist, philosopher, technical writer and consultant, demonstrated a most remarkable intellectual achievement by making public a new and dramatic theory of the universe. Speaking in London at the Northampton College of Advanced Technology, of which he is a governor, Professor R. O. Kapp outlined his theory of continuous creation and extinction of matter, by which he effectively explained the origin and evolution of the planetary system.

Kapp was born in Brentwood, Essex, in 1885, and was educated in Germany and at the University of Birmingham, where his father, Gisbert Kapp, was Professor of Electrical Engineering. From 1909 to 1913 he was employed by Brown, Boveri and Company in Switzerland, being concerned with electrical traction. During the First World War he served as a sniper and scout and later as an officer in the Royal Engineers. Subsequently he returned to Kennedy and Donkin, which he had joined shortly before the outbreak of hostilities, and was responsible to them for the design and supervision of equipment in connection with railway electrification, electric power stations and power transmission, including the British Grid system. In 1935 he was appointed Pender Professor of Electrical Engineering (he later became Emeritus Professor) at University College, London, and in 1946 became Dean of the Faculty of Engineering and a member of the Senate at the University of London. At the end of his term of office in 1950, he was appointed consultant to Kennedy and Donkin.

A member of the Institution of Electrical Engineers, to which he has presented many technical papers, Professor Kapp has also been active in other fields. He founded the Presentation of Technical Information Group and is president this year of the Philosophy of Science Group of the British Society for the History of Science—now in process of becoming the British Society for the Philosophy of Science. His published books include *Science Versus Materialism* and *Facts and Faith*. His recreations are given in *Who's Who* as music and gardening. In *Back to Methuselah*, George Bernard Shaw argued most cogently that human beings would not amount to much unless they succeeded in retaining their faculties to a ripe old age—say 250. Well, we've made a start.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk(*). For details of events not included below, reference should be made to ENGINEERING, *26 December, page 831, and 30 January, page 157. Organisers are invited to send particulars of coming events to the Editor.*

Israel Agricultural Exhibition.—In March, at the Beth Dagan Fair Grounds, Tel Aviv. Organised by the Israel Agricultural and Development Exhibitions Co., Ltd., 2 Carlebach Street, Tel Aviv, Israel.

***Leipzig Spring Fair.**—Sun., 1 Mar., to Tues., 10 Mar., at Leipzig. Fair offices: Postschliessfach 329, Leipzig, Germany. Agents: Leipzig Fair Agency, 127 Oxford Street, London, W1. Tel. GERrard 0357.

AUTOMATIC VENDING

Automatic Vending Exhibition.—First International.—Mon., 2 Mar., to Thurs., 5 Mar., at the Royal Horticultural Society's Old Hall, Vincent Square, London, SW1. Organised by Contemporary Exhibitions Ltd., 40 Gerrard Street, London, W1. Tel. GERrard 4951. (Change of title, dates and venue.)

Smallwares Trade Fair, Sixth.—Mon., 2 Mar., to Fri., 6 Mar., at the Hotel Metropole, Brighton. Organised by Trade and Technical Exhibitions Ltd., 1 Dorset Buildings, Salisbury Square, London, EC4. Tel. FLEet Street 1555.

***Television Society, Annual Exhibition.**—Tues., 3 Mar., to Thurs., 5 Mar., at the Royal Hotel, Woburn Place, London, WC1. Society's offices: 166 Shaftesbury Avenue, London, WC2. Tel. TEMple Bar 3330. (Tickets required).

Ideal Home Exhibition.—Tues., 3 Mar., to Mon., 30 Mar., at Olympia, London, W14. Organised by Associated Newspapers Ltd., 161-163 Queen Victoria Street, London, EC4. Tel. FLEet Street 6000.

***House Journal Editors' Conference.**—Fri., 6 Mar., to Mon., 9 Mar., at the Grand Hotel, Brighton. Organised by the Industrial Welfare Society, 48 Bryanston Square, London, W1. Tel. AMBassador 2401.

Chesapeake Bay Boat Show, Fifth Annual.—Fri., 6 Mar., to Wed., 11 Mar., at the Fifth Regiment Armoury, Baltimore. Offices: 1006 Cathedral Street, Baltimore, 1, Maryland, USA.

***Finnish Industries Fair.**—Fri., 6 Mar., to Sun., 15 Mar., in Helsinki. Organised by Osuuskunta Suomen Messut, Messuhallit, Helsinki, Finland.

VIENNA FAIR

***Vienna International Spring Trade Fair.**—Sun., 8 Mar., to Sun., 15 Mar., in Vienna. Apply to the British Austrian Chamber of Commerce, 29 Dorset Square, London, NW1. Tel. PADdington 7646.

Nylon Fair, Fourth National.—Mon., 9 Mar., to Fri., 13 Mar., at the Royal Albert Hall, London, SW7. Organised by Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

Utrecht International Spring Fair.—*Consumer Goods:* Mon., 9 Mar., to Sat., 14 Mar., at Utrecht, Holland. *Technical Fair:* Wed., 15 April, to Fri., 24 April, at Utrecht, Holland. Apply to Mr. W. Friedhoff, Netherlands Chamber of Commerce, 10 Gloucester Place, London, W1. Tel. WELbeck 9971.

Canadian National Packaging Conference.—Tues. and Wed., 10 and 11 Mar., at the King Edward Hotel, Toronto. Sponsored by the Packaging Association of Canada, 1 St. Clair Avenue W., Toronto 7, Canada.

Philippine-British Trade Show.—Wed., 11 Mar., to Tues., 17 Mar., at the Manila Hotel, Manila. Apply to the Commercial Secretary, British Embassy, Hongkong and Shanghai Bank Building Manila, Philippines.

Inventors' Exhibition, Eighth International.—Fri., 13 Mar., to Sun., 22 Mar., at Brussels. Organised by the Chambre Syndicale pour la Protection des Inventeurs, 70 Rue de Livourne, Brussels.

***Art of Selling, Course on.**—Mon., and Tues., 16 and 17 Mar., at the National Film Theatre, South Bank, London, SE1. Organised by the British Institute of Management, 80 Fetter Lane, London, EC4. Tel. HOLborn 3456.

Oil and Colour Chemists' Technical Exhibition.—Tues., 17 Mar., to Thurs., 19 Mar., at the Royal Horticultural Society's New Hall, Greycoat Street, London, SW1. Organised by the Oil and Colour Chemists' Association, Memorial Hall, Farringdon Street, London, EC4. Tel. CENtral 2120.

Corrosion Show.—Tues., 17 Mar., to Thurs., 19 Mar., at the Sherman Hotel, Chicago. Held concurrently with **15th Annual Conference of the National Association of Corrosion Engineers.** Sponsored by the Association, 1061 M & M Building, Houston 2, Texas, USA.

Electrical Engineers' Exhibition, Eighth.—Tues., 17 Mar., to Sat., 21 Mar., at Earl's Court, London, SW5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (Tel. LANgham 5927) and organised by the Electrical Engineers (ASEE) Exhibition, Ltd., 6 Museum House, 25 Museum Street, London, WC1. Tel. MUSeum 3450.

Agricultural Machinery Exhibition, International.—Tues., 17 Mar., to Sun., 22 Mar., at the Exhibition Grounds, Porte de Versailles, Paris. Organised by the Union des Exposants de Machines et d'Outillage Agricoles, 95 Rue Saint Lazare, Paris 9e.

Concours Général Agricole.—Tues., 17 Mar., to Mon., 23 Mar., in Paris. Apply to the Commissariat du Concours Général Agricole, 72 Rue de Varenne, Paris 7e.

Witwatersrand Easter Show.—Tues., 17 Mar., to Mon., 30 Mar., at Milner Park, Johannesburg. Show incorporates a United Kingdom pavilion. Organised by the Witwatersrand Agricultural Society, P.O. Box 4344, Johannesburg, South Africa.

Radio Engineering Show.—Mon., 23 Mar., to Thurs., 26 Mar., at New York Coliseum, New York. Sponsored by the Institute of Radio Engineers. Organised by William C. Copp Associates, 72 West 45th Street, New York 22, USA.

***Telemetry Symposium.**—Wed., 25 Mar., at 3 p.m. and 6 p.m., at the London School of Hygiene and Tropical Medicine, Keppel Street, London, WC1. Organised by the British Institution of Radio Engineers, 9 Bedford Square, London, WC1. Tel. MUSeum 1901.

Institute of Physics: Stress Analysis Group's Easter Conference.—Tues., 31 Mar., to Sat., 4 April, at the Technische Hogeschool, Delft, Netherlands. Institute's offices: 47 Belgrave Square, London, SW1. Tel. BELgravia 6111.

***Audio Fair, Fourth.**—Thurs., 2 April, to Sun., 5 April, at the Hotel Russell, Russell Square, London, WC1. Organised by Audio Fairs Ltd., 42 Manchester Street, London, W1. Tel. WELbeck 9111. (Alteration of venue.)

***Computers for Use in Production Control, Conference.**—Thurs., 2 April, at Northampton College of Advanced Technology, St. John Street, London, EC1. Organised by the Central London Productivity Association. Apply to Mr. P. R. de Smet, 6 Rowfant Mansions, Rowfant Road, London, SW17.

***Lyons International Trade Fair.**—Sat., 4 April, to Mon., 13 April, at Lyons. Agents: Robert Brandon and Partners Ltd., 47 Albemarle Street, London, W1. Tel. HYDe Park 0901.

Atom Fair and Nuclear Congress.—Sun., 5 April, to Fri., 10 April, in the Public Auditorium, Cleveland. Organised by the International Atomic Exposition Inc., 117 South 17th Street, Philadelphia 3, Pa., USA. Co-ordinating body: Engineers' Joint Council, 29 West 39th Street, New York 12, USA.

World Fishing Boat Congress, Second.—Sun., 5 April, to Fri., 10 April, at the headquarters of the Food and Agriculture Organisation of the United Nations (FAO), Rome. Apply to that organisation.

***Ergonomics Research Society's Conference.**—Mon., 6 April, to Thurs., 9 April, at Balliol College, Oxford. Theme: "Ergonomics—Its Place in Industry." Conference secretary: Dr. S. Griew, Department of Psychology, 22 Berkeley Square, Bristol 8. Tel. Bristol 24161.

***Instrument Show, Fifth International.**—Mon., 6 April, to Fri., 10 April, at the International Instrumentation Centre, 4 Tilney Street, Park Lane, London, W1 (GROsvenor 4567). Sponsored by B and K Laboratories Ltd., 57 Union Street, London, SE1. Tel. HOP 4567.

***Swiss Industries Fair.**—Sat., 11 April, to Tues., 21 April, at Basle, Switzerland. Apply to the Swiss Embassy, 18 Montagu Place, Bryanston Square, London, W1. Tel. PADdington 0701. (Change of closing date.)

LILLE FAIR

***Lille International Trade Fair.**—Sat., 11 April, to Sun., 26 April, at Lille. Agents: Weigel, Leygonie and Co., Ltd., 31-32 King Street, London, WC2. Tel. TEMple Bar 4825.

***Milan International Samples Fair.**—Sun., 12 April, to Mon., 27 April, at Milan. Representative: Dr. V. Schiazzano, 31 Old Burlington Street, London, W1. Tel. REGent 2411.

***Energy Transfer with Special Reference to Biological Systems, Discussion on.**—Tues., 14 April, to Thurs., 16 April, at The University, Nottingham. Organised by the Faraday Society, 6 Gray's Inn Square, London, WC1. Tel. CHAncery 8101.

***Sarrebruck International Samples Fair.**—Wed., 15 April, to Sun., 26 April, at Sarrebruck. Offices: Messegelande, Am Schanzenberg, Sarrebruck.

Engineering Exhibition (22nd Engineering, Marine, Welding and Nuclear Engineering Exhibition).—Thurs., 16 April, to Thurs., 30 April, at Olympia, London, W14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, WC2. Tel. WHItehall 0568.

***Biomechanics, Symposium on.**—Fri., 17 April, at the Institution's headquarters, London. Organised by the Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

***Hanover Trade Fair.**—Sun., 26 April, to Tues., 5 May, at Hanover. Agents: Schenkers Ltd., 13 Finsbury Square, London, EC3. Tel. METropolitan 9711.

***Graz International Spring Fair.**—Thurs., 30 April, to Sun., 10 May, at Graz, Austria. Apply to the British Austrian Chamber of Commerce, 29 Dorset Square, London, NW1. Tel. PADdington 7646.

***Brussels International Industries Fair, 32nd.**—Thurs., 30 April, to Mon., 11 May, at Brussels. Agents: Belgian Railways, 167 Regent Street, London, W1. Tel. REGent 1491.

Electronic Parts Distributors Show.—In May, at the Conrad Hilton Hotel, Chicago. Organised by the Electronic Industry Show Corporation, Suite 1500, 11 South La Salle Street, Chicago 3, Ill., USA.

***Paris International Trade Fair.**—Fri., 1 May, to Mon., 18 May, in Paris. Apply to the French Chamber of Commerce, 74 Brook Street, London, W1. Tel. HYDe Park 2744.

***Valencia International Samples Fair.**—Fri., 1 May, to Wed., 20 May, at Valencia. Offices: Llano del Real 2, Valencia.

***Dublin Spring Show and Industries Fair.**—Tues., 5 May, to Sat., 9 May, at Dublin. Organised by the Royal Dublin Society, Ball's Bridge, Dublin, Eire.

Tokyo International Trade Fair.—Tues., 5 May, to Fri., 22 May, at Tokyo. Organised by the Economic Bureau, Tokyo Metropolitan Government, Marunouchi, GPO Box 1201, Tokyo, Japan.

***United States World Trade Fair, Third.**—Fri., 8 May, to Tues., 19 May, at the New York Coliseum, New York, USA. *Managers:* The Charles Snitow Organisation, Inc., 331 Madison Avenue, New York 17. Information may be also obtained from the British Commonwealth Chamber of Commerce in the United States, 677 Fifth Avenue, New York 22. Agents in UK: Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422. (Additional information.)

MACHINE TOOLS

Sydney Machine Tool Exhibition, Second.—Mon., 11 May, to Sat., 16 May, at the Show Ground, Sydney. Organised by the Machine Tool Division, Sydney Chamber of Commerce, 36 Grosvenor Gardens, Sydney, Australia.

Petroleum Exposition and Congress, International.—Thurs., 14 May, to Sat., 23 May, at Tulsa. Information from Mr. William B. Way, 2104 Philtower, Tulsa, Oklahoma, USA.

***Budapest Industrial Fair.**—Fri., 15 May, to Mon., 25 May, in Budapest. Organised by the Hungarian Chamber of Commerce, Rosenberg hp. u. 17, Budapest.

Transistors and Associated Semi-Conductor Devices, International Convention.—Thurs., 21 May, to Wed., 27 May, at Earl's Court, London, SW5. Organised by the Radio and Telecommunication Section of the IEE. Apply to the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Tel. TEMple Bar 7676. In connection with this convention, an **International Transistor Exhibition** will be held, also at Earl's Court, from Wed., 20 May, to Thurs., 28 May. Organisers: Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

***Foundry Exhibition.**—Thurs., 21 May, to Sat., 30 May, at Bingley Hall, Birmingham.

***Swiss Import Exhibition, Third (ZUSPA).**—Fri., 22 May, to Sun., 31 May, in Zürich. Offices: Nordstrasse 20, Zürich 6, Switzerland.

***Heating, Ventilation and Air Conditioning, International Conference.**—Mon., 25 May, to Thurs., 28 May, in Paris. Organised by the Institut Technique du Batiment et des Travaux Publics, 6 Rue Paul Valéry, Paris 16e. (Alteration of dates.)

***Electro-Heat, Fourth International Congress on.**—Mon., 25 May, to Fri., 29 May, at Stresa, Italy. Apply to the British National Committee, 2 Savoy Hill, London, WC2. Tel. TEMple Bar 9434.

Waikato Winter Show.—Tues., 26 May, to Tues., 2 June, at Blendislow Hall of Agriculture, Hamilton. Agricultural machinery exhibits. Organised by the Waikato Winter Show Association, PO Box 616, Hamilton, New Zealand.

Royal Ulster Agricultural Show, 92nd.—Wed., 27 May, to Sat., 30 May, at the King's Hall, Belfast. Organised by the Royal Ulster Agricultural Society, King's Hall, Balmoral, Belfast. Tel. Belfast 665225.

World Petroleum Congress, Fifth.—Sat., 30 May, to Fri., 5 June, at New York Coliseum, New York USA. Offices of the Congress: 480 Lexington Avenue, New York 17, USA. Apply to the British National Committee, Institution of Petroleum, 61 New Cavendish Street, London, W1. Tel. LANgham 3583.

British Electrical Power Convention.—Mon., 1 June, to Sat., 6 June, at Torquay. Organised by the British Electrical Power Convention, 26-27 Cockspure Street, London, SW1. Tel. WHItehall 1928. An **Electrical Exhibition** in connection with the convention will be held at Torquay during the same period. Organisers: British Electrical Development Association, 2 Savoy Hill, London, WC2. Tel. TEMple Bar 9434.

San Francisco International Fair, First.—Thurs., 4 June, to Sun., 14 June, at Cow Palace, San Francisco. Offices: 325 Pacific Avenue, San Francisco 11, Calif, USA.

***Operational Research Society's Second Annual Conference.**—Wed., 10 June, to Fri., 12 June, at the Old Swan Hotel, Harrogate. Apply to the Society at 64 Cannon Street, London, EC4.

Oregon Centennial Exposition, Portland.—Wed., 10 June, to Thurs., 17 Sept. **International Trade Fair.**—Wed., 10 June, to Wed., 24 June. At the Pacific International Livestock Pavilion, Portland. Organised by the Oregon Centennial Commission, 400 Jackson Tower, Portland, Oregon, USA. UK inquiries to Export Publicity and Fairs Branch, Board of Trade, Theobalds Road, London, EC1. Tel. CHAncery 4411.

***Electrama Exhibition of Electrical Equipment.**—Fri., 12 June, to Sun., 28 June, in Paris. "First general exhibition of the French electrical engineering industries and of the applications of electricity in modern life." Offices: 14 Rue de Magdebourg, Paris 16e.

Information Processing, International Conference on.—Mon., 15 June, to Sat., 20 June, in Paris. Organised by the United Nations Educational, Scientific and Cultural Organisation. An **International Exhibition of Data Processing Equipment** will be held in Paris at the same time. Inquires in UK should be addressed to the honorary secretary, Group B, British Conference on Automation and Computation, c/o the Institution of Electrical Engineers, Savoy Place, London, WC2 (Tel. TEMple Bar 7676); and other inquiries to the Information Processing Department, Department of Natural Sciences, UNESCO Secretariat, Paris.

COMBUSTION ENGINES

International Congress on Combustion Engines.—Mon., 15 June, to Sat., 20 June, at Wiesbaden, Germany. Theme: "Diesel Engines and Gas Turbines up to 1,500 h.p.: Current Problems Concerning Their Design, Production, Development and Running on Site." Apply to the secretary to the national committee, International Congress on Combustion Engines, 6 Grafton Street, London, W1. Tel. HYDe Park 5107.

Plastics Exhibition and Convention, International (formerly the **British Plastics Exhibition and Convention**).—Wed., 17 June, to Sat., 27 June, at Olympia, London, W14. Organised, with the support of the British Plastics Federation, 47-48 Piccadilly, London, W1 (Tel. REGent 4681), by *British Plastics*, Dorset House, Stamford Street, London, SE1. Tel. WATerloo 3333.

***Air Pollution Control Association, Annual Meeting.**—Mon., 22 June, to Fri., 26 June, at the Hotel Statler, Los Angeles, Calif., USA. Association offices: 4400 Fifth Avenue, Pittsburgh, Pa., USA.

Institution of Mechanical Engineers, Summer Meeting.—Mon., 29 June, to Thurs., 2 July, in Zürich. It is hoped that additional pleasure excursions will take place on 3 July. Institution offices: 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

Chicago International Trade Fair.—Thurs., 2 July, to Sat., 18 July, at the Navy Pier Exhibition Hall, Chicago. Organised by the Chicago Association of Commerce and Industry, 30 West Monroe, Chicago 3, Ill., USA.

***Fishing and Allied Industries Exhibition, 19th International.**—Sat., 4 July, to Sun., 19 July, at Ancona, Italy. Apply to the Ancona Chamber of Commerce, Ancona, Italy.

ROYAL SHOW

***Royal Show.**—Tues., 7 July, to Fri., 10 July, at Woodstock, near Oxford. Organised by the Royal Agricultural Society of England, 35 Belgrave Square, London, SW1. Tel. BELgravia 5323.

***Practical Application of Co-partnership in Industry.**—Fri., 10 July, to Sun., 12 July, at St. Hugh's College, Oxford. Organised by the Industrial Co-partnership Association, 36 Victoria Street, London, SW1. Tel. ABBey 3342.

***Fair of Technics and Technical Achievements, Third International.**—Sun., 23 Aug., to Wed., 2 Sept., at Belgrade. Offices: PO Box 408, Beogradski Sajam, Belgrade.

***German Hotel Trade and Catering Exhibition, Tenth.**—Sat., 29 Aug., to Sun., 6 Sept., at Düsseldorf. Agents: John E. Buck & Co., 47 Brewer Street, London, W1. Tel. GERrard 7576.

***British Association Meeting.**—Wed., 2 Sept., to Wed., 9 Sept., at York. Apply to the secretary, British Association for the Advancement of Science, 18 Adam Street, Adelphi, London, WC2. Tel. TRAfalgar 5733.

***Treatment of Waste Waters, Symposium on.**—Mon., 14 Sept., to Sat., 19 Sept., at King's College, Newcastle upon Tyne. Apply to Mr. Peter C. G. Isaac, Department of Civil Engineering, King's College, University of Durham, Claremont Road, Newcastle upon Tyne 1. Tel. Newcastle 29963.

***Agricultural Aviation Conference, International.**—Mon., 14 Sept., to Sat., 19 Sept., at Cranfield. Organised by the College of Aeronautics, Cranfield, Beds.

***Domestic Equipment Fair, Second.**—Thurs., 17 Sept., to Sat., 26 Sept., at Earl's Court, London, SW5. Organised by B. and C.D. Trade Exhibitions Ltd., 194 Bishopsgate, London, EC2. Tel. AVEnue 1444. (Postponed.)

***Preserved Foods and Packaging Exhibition,—14th International.**—Sun., 20 Sept., to Wed., 30 Sept., at Parma, Italy. Agents: Italian Chamber of Commerce for Great Britain, 31 Old Burlington Street, London, W1. Tel. REGent 2411.

In Parliament

PROTECTION RACKET

Dissatisfaction at the rejection of the British tender for the construction of turbines for the Greer's Ferry hydro-electric project has been expressed in Parliament on various occasions. That the uneasiness which the American Government's decision caused has not yet subsided was evidenced by the questions which members of both the principal political parties asked in the House of Commons last week.

Mr. Geoffrey de Freitas (Labour) wanted the President of the Board of Trade to make further representations to the United States, because, he said, the American firm which was awarded the contract had been allowed, as a result of a recent decision by the British Government, to sell certain earth-moving equipment to Britain. This import into Britain had directly resulted in the cancellation of orders for similar equipment produced by a Lincoln company, which firm was already working short time.

Reference was made by the Rev. R. W. Sorensen (Labour) to further refusals of British tenders for the supply of machinery to the United States at prices lower than those of American and other competitors. He considered it to be in the interests of mutual friendship between the two countries that the American Government should explain their position more fully.

Mr. Basil de Ferranti (Conservative) wanted the Government to take action to promote the export of electrical-generating plant to the United States.

TREADING SOFTLY

Representations, said Mr. J. K. Vaughan-Morgan, the Minister of State to the Board of Trade, had already been made, and he did not think that further action was necessary to strengthen the claim which the Government had made on behalf of the English Electric Company. It should be noted that since the liberalisation of the entry of dollar imports, the entry into Britain of all types of earth-moving equipment from America had declined.

The effect of the rejection of the tender on Anglo-American understanding was a matter of public relations for the United States Government rather than for him, but it had to be remembered that the Buy American Act applied only to orders placed by Federal agencies. The United States Government had informed Britain that the tender for the Greer's Ferry Dam did not establish a precedent and that each case would be treated on its merits.

Sales of generating equipment in the United States, he told Mr. de Ferranti, were essentially matters for the individual manufacturer, and strenuous and successful efforts had indeed been made. In that connection, he was glad that the Tennessee Valley Authority had just awarded a large contract to a British company. It was an important event in the trading relations between the two nations.

Mr. de Ferranti stressed that throughout the whole of this subject there was a need to tread softly. He urged that the Board of Trade should consult the electrical industry at all possible stages and Mr. Vaughan-Morgan agreed that such consultation should take place.

EASING FLOW OF TRADE

Attention was drawn by Mr. Albert Oram (Labour/Co-operative) to the decision of the thirteenth session of the contracting governments to the General Agreement on Tariffs and Trade (GATT) that a group of governmental experts should be formed to study restrictive business practices in international trade.

He pointed out that there had been a great deal of discussion by various international bodies during the last decade on the subject of restrictive trade practices between different countries, without any effective action resulting. Since the activities of cartels could so easily frustrate attempts to reduce tariffs and remove quantitative restrictions, would the Government ensure that this country took a full and vigorous part in those discussions. The Scandinavian countries, which had been left to take the lead in these matters in the past, should be firmly supported.

Mr. Vaughan-Morgan replied that invitations to governments to nominate representatives to serve on the group of experts had not yet been issued. Any proposals which might emerge from the experts' studies would be examined by the British Government in the light of whether concerted international action was practical or needed. The convening of the group of experts and the nomination of persons to serve on it, however, had been left in the hands of the executive secretary of GATT.

MOTORS IN THE COMMON MARKET

There was a likelihood, said Mr. Maurice Edelman (Labour), of the introduction of the European Common Market having an adverse effect on the British motor industry. What reduction did the President of the Board of Trade expect to take place in British motor-car exports to the countries concerned and what action was being taken to offset any disadvantageous consequences?

Mr. Edelman pointed out that the Scandinavian countries had been discussing the formation of a northern association and said he considered that the President of the Board of Trade should approach the Scandinavian countries, to see whether the importation of British cars to those countries might be enlarged by means of bilateral or multilateral countries.

In reply, Mr. Vaughan-Morgan agreed that the reduction of tariffs and the extension of quotas, if confined to trade between Common Market countries, would place British industry at a disadvantage. He could not assess the effect which these events might have on Britain's motor-car exports, but the Government of this country would continue to work in Europe to bring about solutions which would avoid such developments as were envisaged.

BUILDING UNDER COVER

Mr. Ronald Russell (Conservative) asked the Minister of Housing and Local Government about the use which was being made in Canada of large transparent plastics tents to enclose house-building construction, thereby permitting work to continue during bad weather. He felt that, in order to reduce costs, the Minister should advise the local housing authorities in Britain to consider the use of similar devices. Mr. Henry Brooke replied that climatic conditions in Canada, especially in winter, were such as to necessitate the use of special building methods and equipment which would not be applicable in the United Kingdom. A small number of builders over here were using equipment of the type to which reference had been made, but his information was that more experience was required before it could be seen whether the general use of such methods in this country would be economic.

JODRELL BANK TELESCOPE

The world-wide prestige and authority which is now enjoyed by the radio telescope at Jodrell Bank was referred to by Lieut.-Colonel W. H. Bromley-Davenport (Conservative), who asked the Parliamentary Secretary to the Ministry of Works what action he proposed to take to ensure that this desirable state of affairs continued. Colonel Bromley-Davenport also wondered whether a sufficient proportion of the International Geophysical Year had now elapsed to enable the Minister to obtain a better estimate of the telescope's value.

Replying as representiave in the Commons to the Lord President of the Council, Mr. Harmar Nicholls stated that all reports so far received by the Council of Scientific and Industrial Research demonstrated the great value to research of "this fine instrument." He was certain that its inherent merit would continue to ensure its prestige and authority. As stated on a former occasion, the DSIR had funds at its disposal for the financing of research of special timeliness and promise. Any applications which the University of Manchester might put forward for grants for future research work involving the use of Jodrell Bank telescope would be considered on their merits.

One such grant, for a sum of £15,200, had in fact recently been awarded and further applications from Manchester University were under consideration by the Council. As regards capital grants, he had nothing to add to his statement in the adjournment debate on the Government's aid to science, which took place on 18 December, 1958. On that occasion, Mr. Nicholls stated that the Government had contributed £350,000 towards the project (one-half of the original estimated cost). It was pointed out in the debate that over the eight years of construction and improving the telescope, however, the cost had risen by £130,000. On that aspect Mr. Nicholls had said that when the Treasury assured the Public Accounts Committee that there was no contemplation of the £130,000 being met out of moneys voted by Parliament, the Committee, with one exception, had welcomed the answer.

SUPERVISION OF SCIENTISTS

A suggestion was made by Mr. Austen Albu (Labour) that there have been "very serious losses" of senior scientific staff at Harwell and that these losses were causing "very great concern." He asked the Prime Minister if he were aware that it was said that these losses were due to the establishment being dominated by the accountancy and administrative staff, with the result that the scientists were no longer able to get on with their job of research.

Mr. Albu asked for information about the number of heads of divisions, or scientists at similar levels, who had left Harwell during each of the last two years. He also wanted to know what increases there had been in the numbers of senior scientific and technical staff and of senior administrative staff.

In answer to these points, Mr. Harold Macmillan said that departures from Harwell and increases in staff were matters of day-to-day management of the United Kingdom Atomic Energy Authority in which he did not regard it as his duty to intervene. He was not aware of what Mr. Albu had suggested were the causes of the losses. There were difficulties of course, and there had been movements of staff, some of which had been of value, into industry and the universities. Certainly, under the present arrangements, there had been a very great advance in the management of atomic affairs by the independent authority.

Applying Automation

The application of automatic techniques in industry, Mr. Vaughan-Morgan told Mr. Sydney Silverman (Labour), was mainly the responsibility of industry itself. Economies in direct labour requirements resulting from automation should be balanced by other factors which would lead to increased employment, such as larger demands for equipment and rising sales due to lower costs. It was recognised that temporary disturbances in employment might be caused in certain industries and in certain areas.

Traffic Engineers

The House was told by Mr. G. R. H. Nugent, Joint Parliamentary Secretary to the Ministry of Transport, that the Traffic Engineering Branch at the Ministry's headquarters was staffed by one assistant chief engineer, four senior engineers, six engineers and four assistant engineers, all of them qualified either as civil or electrical engineers, by corporate membership of the recognised professional institutions. The duties of the branch, he informed Mr. Ernest Davies (Labour), were to apply the techniques of traffic engineering to ensure that the maximum use was made of the existing pattern of roads.

Management

COMPANIES IN THE COMMONWEALTH

With so much talk of the Free Trade Area and Common Market of Western Europe, it would be easy to forget that some notable British engineering firms have established themselves firmly in the Commonwealth. By so doing they are actively helping to create a pattern of working partnerships—among advanced and underdeveloped countries—which will go far to reduce the buffetings of international politics. The United Kingdom has a stake in the Commonwealth and, apart from purely commercial considerations, can contribute to the development of those countries, with the satisfaction of participating in new growths throughout the world. This is the fifth of a number of articles in which the present position and prospects of British engineering firms in the Commonwealth are examined. The previous four, published on 15 August, 1958, 19 December, 1958, 16 January, 1959, and 13 February 1959, considered Hawker Siddeley; Oldam and Son Limited; Ruston and Hornsby Limited and Vickers Limited.

5—Crompton Parkinson Limited

Electrical engineering has not previously figured in this series, and the company selected is a medium-sized concern with a working capital of nearly £10 million and a net profit of over £1 million in the year ended June, 1958. It obviously cannot, therefore, compare in size with say, the English Electric Company, whose profit is over six times as large, but it is a group having a broadly based range of products with extensive overseas trade and interests. To describe these interests would reduce the account to a catalogue of electrical engineering products, but it is as well to draw attention to some of the company's activities apart from the production of a wide range of standard electrical plant and equipment.

The most recent extension of their business came last year when they joined with Richardsons Westgarth; Holland & Hannen and Cubitts; International Combustion; the Fairey Aviation Company; Trollope and Colls; and Elliott Brothers to form the fifth of the impressive consortia in the field of Atomic Energy, this group being entitled Atomic Power Constructions Limited. So far, they have not obtained an order but from the trend of events in the past it seems likely that when the new power project for Wales is approved it will go to them.

The firm are also one of the members of Rustyfa Limited, a consortium founded in 1957 for the purpose of supplying plant and equipment for a tyre factory in the Ukraine. Other members of the consortium include David Bridge and Company Limited, Francis Shaw and Company Limited, Lancashire Dynamo Holdings, Mather and Platt Limited and Simon Handling Engineers Limited. So far orders received have amounted to £14 million.

For some years Cromptons have had an interest in mechanical handling, producing, in co-operation with the Austin Motor Company Limited, the Stacatruc fork-lift trucks. They have now made an agreement under which the Clark Equipment Company of America has taken an equal share with the two English companies in ITD Limited, which was established by the latter some two years ago to market throughout the world a range of fork-lift and industrial trucks. Crompton and Austin also co-operate in the production of Morrison-Electricar delivery vehicles.

Crompton Parkinson stud welding equipment has been widely accepted for a number of years. The use of this plant in shipbuilding and constructional work enables a much improved method of operation to be adopted and there is no doubt that it will continue to be extensively used. The group also manufactures lead acid batteries for both cars and commercial vehicles, and cables.

The British electrical engineering industry as a whole is reputed to have a turnover of £1,200 million per annum. About 20 per cent of this total covers exports, three-fifths of which go to Commonwealth markets. The larger companies in the industry, of which Crompton Parkinson is obviously one, probably have a rather greater proportion of exports, a figure of 40 per cent being more likely.

British equipment has always enjoyed a very high reputation for quality which tends to be reflected in higher costs, but the fact that British companies have won contracts in many of the more difficult markets in the world in the face of competition from American, Swedish and Swiss manufacturers indicates that they have a vigorous attitude to the export trade. In some Commonwealth countries, for instance in Australia and New Zealand, British manufacturers are often suspected of level tendering, if not openly at least by private agreement, but it is difficult to reconcile this with the fact that they are open to undercutting from other countries.

South Africa is a very important Commonwealth market. The total requirement for electrical goods is probably of the order of £50 million per annum, of which about 60 per cent is imported and 40 per cent is supplied from local manufacture. The United Kingdom supplies about 75 per cent of the imports, the remainder being spread between a large number of other countries. There are perhaps nine important electrical manufacturers in the Union, many of whom are subsidiaries or otherwise connected with overseas companies. It would appear that some of these manufacturers have difficulties in trying to compete with imported products. In many cases the market is very small and will not allow the introduction of mass production methods which are essential to cheap production; small electric motors are a case in point.

Where the larger type of apparatus is concerned, South African manufacturers have other troubles. Skilled labour is very expensive and not easy to find. Freight charges are also high, and it is actually cheaper to ship a machine from Europe than it is to transport it from the centre of the country, where a number of the factories are situated, to the coast by railway.

Again, there is the problem that raw materials purchased in small quantities are more expensive; European manufacturers will always enjoy a price advantage on this account. Since local production is seldom cheaper than similar articles shipped from Europe, the Union is unable to build up its own export trade to increase the output. The South African Government appear to appreciate the difficulties of local manufacturers and yet are reluctant to impose import tariffs to allow local products to compete in price with overseas articles, presumably because this would inevitably tend to increase the price of the goods, to reduce competition and possibly to encourage inefficiency among the local manufacturers.

The experience of Crompton Parkinson in the Union illustrates the general situation outlined above. In 1952, they set up a small factory for the manufacture of electric motors in association with Lancashire Dynamo Holdings. After several years, in spite of some apparent success at the beginning of the venture, they were forced to the conclusion that it would never become really profitable and the factory and buildings were sold in 1957. The group have, however, been able to obtain in recent months, and in the face of local competition, valuable orders for switchgear and transformers, which they will supply from the United Kingdom.

The demand for electrical equipment is much larger in Australia where home production amounted to £A70 million in 1952 and by 1958 has probably risen to about £A90 million a year. Imports in the year 1956/57 were £A35 million, the majority of which came from the United Kingdom, although in certain sections there was important competition from American and Continental concerns, and especially the Swedish company ASEA. The production of electrical equipment in Australia is centred in New South Wales and many of the manufacturers are associated with United Kingdom compaies.

Crompton Parkinson are no exception to this generalisation, having three factories all in New South Wales, producing motors, transformers, control gear and switchgear. The site at Campbelltown is a large one and it is expected that the Group will expand production there over the course of the next few years. These factories employ over 1,000 people, and for the products which they handle they are thought to be the largest manufacturers in the country. It is probable that their turnover in Australia is of the order of £A3·0 million. Local manufacturers will always have difficulty in competing on price with imported goods since the Australian market is too small to permit the economies of large-scale production to be achieved, and labour costs also are very high. The Government seem much more willing to assist local manufacturers by the imposition of tariffs and import quotas than is the case in South Africa, although the industry is big enough to feel some measure of competition within itself.

Because many of the Australian manufacturers are subsidiaries of British or other foreign concerns, they are often prevented from attempting to obtain export business and must restrict their trade to the home market. During 1957, a number of Australian industries, including electrical engineering, operated at about only 80 per cent capacity.

Broadly speaking, Australia must be regarded as a good market for electrical goods. The country naturally looks to electricity for much of its fuel and power supplies, including such hydro-electric developments as the Snowy Mountains scheme. In other parts of the continent, the possibility of supplying electric power from medium-sized nuclear power stations would appear attractive and when such schemes mature, Crompton Parkinson should stand an excellent chance of obtaining the business.

Crompton Parkinson also owned for some years a manufacturing unit in New Zealand but were forced to close this in 1954, since they were unable to secure sufficient government support to enable operations to continue on a sound basis. This underlines the fact that local manufacturing in even rapidly developing countries with a small population can only be successful where there is tariff support.

Crompton Parkinson opened a Canadian factory in 1956 at Brantford, Ontario, for the production of switchgear, but it is as yet too

Continuing

Crompton Parkinson Ltd.

early to say how this venture will fare. It faces a number of difficulties. Since there are local standards it is more or less necessary to manufacture especially for this market which, although growing rapidly is still relatively small. Competition from American manufacturers is also serious and where the electrical equipment is to be used in conjunction with other plant, which may have been designed under American influence, there is a natural tendency to buy from American sources.

Canada is well provided with hydro-electric power and the country is likely to provide a growing market for electrical machinery and equipment. Whether this will justify a long term policy of establishing a highly diversified electrical engineering industry formed from subsidiaries of British companies who could supply the Canadian demand from the United Kingdom factories, seems like being worked out by a process of trial and error. A company setting up a Canadian subsidiary can clearly expect to benefit from a preference for locally manufactured products and may also derive some advantage from being able to offer quicker delivery. In the conditions prevailing in 1956, an important consideration may well have been the relative ease of recruiting the necessary labour in Canada as compared with the United Kingdom, but if the pressure on British industrial resources continues to decline, this advantage together with that of quick delivery may become of much less importance.

In his review issued with the 1956-57 accounts, the chairman of Crompton Parkinson said that while the Brantford factory had proved its ability to operate profitably, it was at the end of 1957 working on an order book which was insufficient for its most efficient operation. He referred to severe competition and the cautious mood of Canadian business sentiment but expressed the view that with a resurgence of Canadian business activity, an increased flow of orders would enable the factory to justify its early promise. More recently, the chairman has stated that the problems had not been reduced. Costs, however, had been cut, and the range of products widened, thereby minimising the difficulties.

The Indian economy is dominated by the fact that while the country is making great efforts to improve the standard of living of the very large population, it is at the same time pursuing an acutely nationalistic economic policy. Crompton Parkinson have, therefore, in company with a number of other important British and foreign concerns, set up factories in India. The group have been operating one large plant in Bombay for many years, and during 1958 completed and commissioned another plant in Kanjur. At the moment, the local company employs nearly 2,000 people and the range of products includes motors, fans, transformers, switchgear, and control gear.

Demand for electrical machinery and equipment is likely to increase more rapidly in India than in other Commonwealth countries. Imports at present are valued at about £30 million of which the greater part is obtained from the United Kingdom. In spite of the growing demand for electrical goods, however, the future for Crompton Parkinson and for other British companies with Indian subsidiaries, is problematic. It is clear that if they are to continue to obtain a fair share of the business available it must be with equipment manufactured in the country, so that considerable expansion of their existing plant will be required. Many other companies are anxious to obtain this business, however, and competition will increase not only from traditional rivals but also from electrical engineering concerns in Eastern European countries. At the same time, the Government is setting up publicly-owned factories to make much of the heavy equipment, assistance being afforded by AEI, and although it is expected that the increase in the demand will be such that some of the heavier equipment must still come from private industry, there is a definite trend towards confining the latter to the manufacture of smaller items.

Against these difficulties may be set the advantage that a company manufacturing in India can export some of its output to markets such as China, the Middle East and South-East Asian countries. Indian factories may, in fact, enjoy some preference in these countries as compared with producers in the United Kingdom. Although in the initial stages the electric power requirements of India are likely to be met largely by hydro-electric schemes.

Crompton Parkinson's experience of production in the Commonwealth thus varies with the territory. In India, where the demand for the company's products is increasing, the capacity of the Bombay works has been expanded and an additional factory built and commissioned—the two manufacturing units now being controlled equally by the company and its Indian associate. In Australia, the manufacturing ventures have been successful, but they have not been so in New Zealand and South Africa. In Canada the recent reduction in the rate of industrial expansion has caused a temporary setback and a fall in production below the level necessary for the most efficient operation of the plant. It is not easy to choose the right moment to start production in developing Commonwealth countries but British manufacturers with an important export trade to these countries cannot risk the loss of markets through allowing competitors to set up local manufacturing units. Companies such as Crompton Parkinson which establish local factories at an early stage should reap the benefits of their policy, if they can weather the initial difficulties.

Design

THE BRITANNIC AIR-FREIGHTER

The Britannic freighter which, it has been announced recently, has been ordered for RAF Transport Command from Short Brothers and Harland Limited, Belfast, is based upon the use of the Britannia wing and systems (already in production at Belfast) with a specially designed and entirely new fuselage of very large dimensions with a rear loading door. The aircraft is to be powered by four Rolls-Royce Tyne turboprops.

Project design work has been in hand for over 18 months, detailed market survey of the precise needs of military and civil operators for more than a year, and the design itself has been actively pursued for some six months. The first prototype aircraft is due to fly in April, 1961. Production plans are being studied at the moment and it is hoped that production aircraft will become available towards the end of 1961 or early 1962. The use of many Britannia parts in the Britannic means that it can be developed at much less cost than an entirely new aeroplane. The cost of providing spares and maintenance bases along the routes over which it will operate alongside Britannias will also be reduced.

The Britannic uses the standard Britannia wing and tailplane; an undercarriage almost identical with that of the Britannia, but installed in the fuselage instead of the wings; and many of the standard systems such as fuel, controls, electrics and the flight deck installation itself.

The span is 148 ft 3½ in, the overall length 134 ft, and the height 47 ft. The new fuselage is 17½ ft in diameter and has a rear loading door to enable freight to be loaded and unloaded rapidly. Military loads can also be parachuted —an essential feature of a military freighter. The fuselage floor itself is at " truck bed height " to facilitate loading and unloading. The volume and cross section of the fuselage of the new freighter are among the largest in the world, the clear hold dimensions being 12 ft by 12 ft by 80½ ft.

The design all-up-weight is 195,000 lb. A maximum payload of 75,000 lb can be carried at a mean speed of 360 m.p.h. over a still air range of 1,400 miles. With full fuel tanks, 30,000 lb of payload can be carried over 5,500 miles. The aircraft is capable of delivering a 33,000 lb payload to a 1,000 yard strip advance base 860 miles from main base and to return either empty or with a payload of 30,000 lb.

The aircraft is fully pressurised to maintain a cabin altitude of 8,000 ft at all altitudes up to 30,000 ft. The rear door can, however, be opened in flight for parachuting of large loads. The crew compartment seats a maximum of five. The captain and second pilot have full dual controls and both can reach all normal and emergency controls. The navigator is positioned on the port side, a flight engineer to starboard behind the second pilot, and the radio operator whose station is to starboard, faces aft.

Behind the flight deck is a permanent galley and lavatory section and a staircase leading to an upper deck. In the troop transport role a detachable second floor can quickly be fitted to the forward end of the fuselage hold allowing a total of about 200 troops to be carried in comfort. Normally, 140 troops can be carried on the main floor alone.

The aircraft hold has a flat, level floor with a 2 ft high skirting on each side. The top of this skirting provides a walkway giving access to the hold when loaded. In addition to the freight floor of the hold itself, which is 60 ft long, there is a further 20 ft length of sloping floor, 12 ft wide, which forms the loading ramp and can be used for loading and carrying freight. Head room on the centre line at the extreme aft end of this floor is 10 ft 6 in.

The ramp loading door is controlled by hydraulic rams. Vehicles can be driven up the ramp, or the ramp can be lowered part way so as to rest on the bed of a lorry and provide an approach for loading. To facilitate the loading of smaller freight, a side door 7½ ft by 8½ ft is provided in the fuselage at the forward end of the hold. A grid of standard lashing points extends over the interior floor and up the side of the wall to a height of 4 ft. The permissible load alternates between 5,000 lb and 10,000 lb on the floor and is 2,000 lb on the walls. Further points of 25,000 lb and 35,000 lb are provided for special cases.

Heavy military equipment dropped by parachute is lashed on a strong platform fitted with air packs on the underside. These inflate automatically during descent and break the fall of the platform. The parachutes are stowed on top of the load. The Britannic can carry four such platforms each 16 ft long, or two 24 ft platforms of a type now under development. Additional side doors permit parachute troops to jump.

The S.C.5 would be capable of carrying the following typical loads: two 1 ton trucks (laden), two 25-pdr. guns, and one scout car (laden); or four 1 ton trucks (laden), and three 3 ton trucks (laden); or two scout cars (laden), two ¼ ton utilities (laden), and two ½ ton trailers (laden).

The Britannic is also capable of carrying large special vehicles, such as a 30 ton heavy artillery tractor, 10 ton Albion crane, 10 ton Leyland refueller, and large radar trailers used with guided weapon installations.

As a passenger transport, the Britannic can carry the capacity payload of 197 passengers at over 350 m.p.h. over still air range (no allowances) of 2,600 miles for a direct operating cost of 0·77*d*/seat mile. With fuel tanks full, 90 passengers can be carried over still air range of 5,450 miles.

Continuing **Design**

LIMIT DESIGN OF FRAMED STRUCTURES

Characteristics of Imperfectly Plastic Materials

By Dr. JACQUES HEYMAN, Department of Engineering, University of Cambridge

A STRUCTURE, in order to be satisfactory, must fulfil three major design criteria. First, the structure must be capable of withstanding the given design loads; this is the requirement of *strength*. Secondly, deflections under the given loads must not exceed certain specified amounts, or the function of the structure may be impaired; this is the requirement of *stiffness*. Last, the structure as a whole must not become unstable, either in the sense of local or overall buckling, or in the sense of "overturning" (as a retaining wall might overturn due to earth pressure); this is the requirement of *stability*.

Considering first a structure which remains entirely elastic under load, the closeness with which the structure satisfies the three criteria can be calculated with more or less accuracy. The stability load can be calculated most closely; an overturning load is the solution of a simple statical problem, in which the equations involve known dimensions and reasonably well known loads. Local buckling involves geometrical properties of the members and the elastic constants for the material, and while the theory may lead to transcendental equations, the problem can theoretically be solved.

RULE OF THUMB METHODS

Deflection calculations do not agree so closely with observations on an actual structure. Assumptions must be made in the calculations as to the behaviour of certain portions of the structure; for example, supports will be assumed rigid or to sink specified amounts; joints will be assumed rigid, or of known flexibility; perfect fit-up will be assumed, so that no prestress (or specified prestress for concrete) is induced, and so on. None of these assumptions (which will be referred to as those of compatibility) will be realised exactly in practice, and some will be realised only very approximately. However, since deflections are usually calculated from a second order differential equation, the process of double integration leads to more accurate estimates, and the calculated overall stiffness of a structure can usually be accepted.

For a purely elastic structure, the strength will be estimated on the attainment of a specified limiting stress for the material. The fact that the usual structural assumptions are not realised in practice will lead to large deviations in observed and calculated stresses, and *prima facie*, the usual strength calculations are almost worthless. However, it should be noted immediately that structures designed in accordance with normal building codes, which are based on the elastic concept of a limiting working stress, do not usually fall down. Further, a structure to carry the given loads designed by the more rational and accurate limit or plastic method will very often differ only slightly from the same structure designed elastically. Thus it appears that "rule-of-thumb" design methods, while calculating quantities which may be almost completely fictitious, do in fact lead to a fairly trustworthy structure.

LIMIT OR PLASTIC DESIGN

In England, the Steel Structures Research Committee carried out tests on real structures, and found that stresses and corresponding bending moments bore almost no relation to those calculated.[1] An account of the work has been given by Professor J. F. Baker.[2] The investigators of the Committee realised that any further refinements in elastic calculation were useless; a real structure was too complicated, and in practice did not satisfy the design assumptions, for any modification of existing theory to lead to greater accuracy. Accordingly, Baker picked up the threads of earlier German, Austrian, and English work on the plastic properties of steel. An account of the development of a rational limit design method for steel framed structures, finally allowed by British design codes, has been given by Baker *et al.*[3]

Simple plastic design methods are concerned entirely with the strength of the structure. They concentrate on the calculation of ultimate carrying capacity (collapse load) and make no attempt to estimate deflections. In fact, one of the assumptions is that deflections, whether elastic or plastic, are small compared with the overall dimensions of the structure. (This is, of course, the normal structural assumption for strength calculations.) It may be noted that an *elastic* design must satisfy the three conditions of equilibrium, compatibility, and a stress-strain law.

The equilibrium condition states that the internal actions (shear forces, thrusts, bending moments) must be in equilibrium with the external loads on the structure. The stress-strain law will be known for a given material. It is the compatibility condition, involving assumptions as to rigidity and initial conditions, as mentioned above, which makes elastic calculations suspect.

By contrast, a *plastic* design must satisfy the three conditions of equilibrium, mechanism, and yield. Confining the discussion to the behaviour of framed structures, the yield condition may be interpreted as the knowledge of the full plastic moments of the members used. The elastic compatibility condition is replaced by the mechanism condition: sufficient plastic hinges must be formed to turn the structure, or part of it, into a collapse mechanism of one or more degrees of freedom. It is this which makes plastic theory so accurate in calculating the strength of a structure; compatibility conditions, those most difficult to satisfy in practice, do not enter the calculations. A joint between two members, for example, can have any flexibility (providing overall deflections remain small); the only requirement is that the joint be sufficiently *strong* to develop the full plastic moment of one of the members, if a plastic hinge is indicated at that cross-section. The collapse load will then remain entirely unaffected by the precise moment-rotation characteristics of the joint.

DESIGN TECHNIQUES

The elastic design procedure may be described more correctly as one of analysis. For any structure other than the simplest beam, the designer will guess the sizes of the members, and then make a stress analysis to check that the permissible value is not exceeded. Thus the process is one of trial and error, the three requirements of equilibrium, compatibility, and the stress-strain law being satisfied at each stage.

By contrast, plastic design is so much simpler that very often direct designs are possible; in particular, design for minimum material consumption may be made, either using prismatic members[3,4] or with continuously varying cross-sections.[5] If the minimum-weight design is not required, then a way of designing a frame of given outline made of elastic—*perfectly* plastic material, acted upon by given loads, is as follows:

Any one equilibrium distribution of bending moments is constructed, by combining the free bending moments with those due to arbitrarily chosen values of the redundancies. Material is then assigned such that the full plastic moment of each section is just equal to the equilibrium bending moment at that section. Every section of the structure is a "hinge," and the requirements of equilibrium, mechanism and yield are satisfied.

Such a design, requiring continuously varying cross-sections, is impracticable. An alternative design method starts by constructing a mechansim of one (or more) degrees of freedom for the given frame outline. The bending moments at the hinges of this mechanism may be determined (not necessarily uniquely) such that equilibrium is satisfied, and so that the whole bending moment distribution is statically determinate. At cross-sections for which no hinge was assumed, the members may be proportioned to have full plastic moments greater than those dictated by the equilibrium bending moment distribution; at the indicated hinges, the members are proportioned to have the required full plastic moments. For this type of design, prismatic members (possibly with sudden changes in cross-section) may be used.

BEHAVIOUR OF A PERFECTLY PLASTIC FRAME

Consider a frame, which has been designed by a plastic method, subjected to loads which increase proportionally from zero up to the collapse value. Except by accident, the elastic distribution of bending moments in the frame will not be proportional to the (arbitrarily chosen) collapse distribution. Thus, as the loads are slowly increased, at some value below collapse plastic flow will occur at one or more cross-sections of the frame; indeed, such flow could occur at working values of the loads. For a frame made of perfectly plastic material, such plastic flow is "safe," since indefinite rotation can occur at a plastic hinge at *constant* moment (the full plastic moment). In fact, a cross-section which has become plastic offers zero resistance to further incremental loading; increase of applied load must therefore be resisted by an increase in bending moment at other critical sections of the frame. A second plastic hinge will form, and so on until the collapse load is reached. The magnitude of the collapse load is quite unaffected, according to the simple theory, by the order of formation of the plastic hinges. It is this which makes it unnecessary in practice to follow the history of loading, and which makes it so simple to design on the collapse values of the loads.

STRAIN-SOFTENING MATERIALS

The moment-rotation curve for a cross-section of a member made of reinforced concrete is usually not perfectly plastic. Under certain

Continuing **Design**

conditions of reinforcement, the bending moment starts to decrease with increasing curvature, instead of staying constant at the full plastic value. If a design is carried out according to simple plastic theory, therefore, the resulting structure must be suspect since one of the fundamental assumptions of the theory is not satisfied. If plastic rotation occurs at a cross-section under the working values of the loads, such plastic flow may be "unsafe" if the curvatures are such that the falling portion of the moment-rotation curve is reached. Professor A. L. L. Baker has developed a design method for reinforced concrete which calculates hinge rotations at collapse of the frame; the frame is modified if these rotations are too large.[6] Again, these calculations depend on assumed compatibility conditions to which an actual frame will not conform, and the value of making very precise computations may be doubted.

One way of avoiding (apparently) the danger of premature failure of a cross-section, due to large plastic rotations under working loads, is to ensure that the elastic and collapse distributions of bending moment differ only by a scale factor (the load factor), i.e., that the two distributions are similar. If this could be done (presumably by somewhat lengthy design procedures, if at all), then all assumed hinge sections would develop simultaneously, and there would be no danger in using an imperfectly plastic material. The idea that danger is in fact avoided by this solution is illusory. Once again, the assumed compatibility conditions (rigid supports, joints, etc.), which are used in determining the elastic bending moments, will be realised only very approximately in the real structure; even slight imperfections will lead to an elastic bending moment distribution which is markedly different from that calculated.

MINIMUM WEIGHT STRUCTURE

There is one class of structure, of course, for which the elastic solution does not use compatibility conditions; that is, the statically determinate structure. For a frame of this type, imperfect materials may be used with confidence; then, however, plastic design will not differ from elastic design. (It is noteworthy that of all possible designs of a structure of given outline, that one will have absolute minimum material consumption which is statically determinate, providing certain assumptions are made.[5, 7] Thus, if strength were the *only* criterion for design, the designer might well consider the use of statically determinate frames. Unfortunately, the simple plastic theory, which ignores deflections, works so well for redundant frames because deflections are in fact reduced by virtue of the redundancies; a statically determinate frame may lead in practice to disturbingly large deflections, as well as being more liable to failure by instability.)

All these arguments seem to lead to the conclusion that simple plastic theory is the wrong basis for design of structures made of strain-softening materials like reinforced concrete. One might be tempted further to assert that reinforced concrete itself is a dangerous material to use for framed structures; since experiments on actual frames show that designers can estimate only poorly the bending moment distribution under working loads, it is very likely that potentially dangerous conditions of plastic flow can develop. The experienced steelwork designer is not worried by such considerations; although the stress analyst may tell him that a small hole in a stress field produces a stress concentration factor of 3, he knows that (safe) plastic flow will allow him to insert bolt holes at joints with relative impunity.

The concrete designer also feels that a small amount of plastic flow is not harmful, and a strong qualitative (if teleological) argument can be advanced in his favour, and to defend the use of reinforced concrete as a structural material. While a concrete frame may not be quite so strong as the designer believes, reduction in strength may often be small. Suppose, as the loads on a frame are increased, some plastic deformation occurs at one cross-section. Exactly as for the case of perfectly plastic material, that critical cross-section becomes very flexible, and any increase in load must now be carried almost entirely by other portions of the frame. As a second hinge forms, moment is again "thrown off" to the remaining critical sections, and the bending moments are again redistributed. The process continues, and the calculated collapse load can be approached closely; relatively small rotations at the hinges already formed will be sufficient to cause large increases of bending moment at the remaining elastic critical sections. Unless the first hinge forms very early in the loading history, and is most unfavourably placed, it is unlikely that such severe rotations will occur that the moment falls appreciably.

STRAIN-HARDENING MATERIALS

A material like cast iron, which shows no appreciable plastic deformation, illustrates the dangers of using brittle materials. No designer would now dare to erect a cast iron redundant structure, even though his stress calculations indicated that the structure were safe. Due to imperfections in fit-up, the structure would probably crack when the bolts were tightened. Even if erection could be completed, slight sinking of supports under light load would cause such high stresses that fracture would occur. These considerations raise the question as to the extent to which strain-hardening materials (high tensile steel, aluminium alloys) may be used in structural design.

If a beam of high tensile steel is tested in bending, the initial response is of course elastic. Some plastic deformation then occurs at increasing applied moment, the rate of increase of curvature becoming larger. Eventually an ultimate bending moment is reached at which fracture occurs. Is there any danger of such fracture occurring at a critical section of a framed structure?

The answer is almost certainly no, if the tensile strain at fracture of the material is greater than a very few per cent. With even a small ultimate elongation of the material, very large rotations must take place before a "hinge" fractures in bending. Furthermore, on loading a frame made from strain-hardening material, such large rotations at critical sections will again permit the bending moments at more lightly stressed cross-sections to increase rapidly, and a large measure of moment equalisation will take place. Simple theory may be used for the design of such frames; the full plastic moment will be taken somewhere between the yield moment and the ultimate. The actual frame will then carry, in general, the calculated collapse load without fracture occurring.

CONCLUSIONS

A rational design method, based on the strength of a structure, and ignoring the criteria of stiffness and stability, cannot use the conventional concept of limiting stress. The practical imperfections of a real frame are such as to cast serious doubt on the accuracy of stresses calculated by an elastic analysis. On the other hand, plastic design methods have been demonstrated experimentally[3] to predict closely collapse loads for frames made of structural mild steel, an almost ideally plastic material.

It is believed that the same simple plastic method can be used if the material is imperfectly plastic, either strain-softening or strain-hardening. Any plastic flow at critical sections will cause the bending moment distribution at collapse to approximate more or less closely that determined by simple plastic theory, and there is little danger of local failure due to excessive plastic rotation.

REFERENCES

[1] Steel Structures Research Committee. HMSO London. First Report (1931), Second Report (1934), Final Report (1936).

[2] J. F. Baker, *The Steel Skeleton*, volume 1, Cambridge University Press (1954).

[3] J. F. Baker, M. R. Horne and J. Heyman, *The Steel Skeleton*, volume 2, Cambridge University Press (1956).

[4] J. F. Foulkes, "The Minimum Weight Design of Structural Frames." *Proc. Roy Soc.* A, vol. 223 (1954).

[5] J. Heyman, "On the Absolute Minimum Weight Design of Framed Structures." To be published.

[6] A. L. L. Baker, *Ultimate Load Theory Applied to The Design of Reinforced and Prestressed Concrete Frames*. Concrete Publications Limited, London (1956).

[7] J. Barta, "On the Minimum Weight of Certain Redundant Structures." *Acta Tech.*, Acad. Sci. Hungary, vol. 18, pp. 67-76 (1957).

LOCOMOTIVE FOR ANYWHERE

Overseas Operation as a Condition of Design

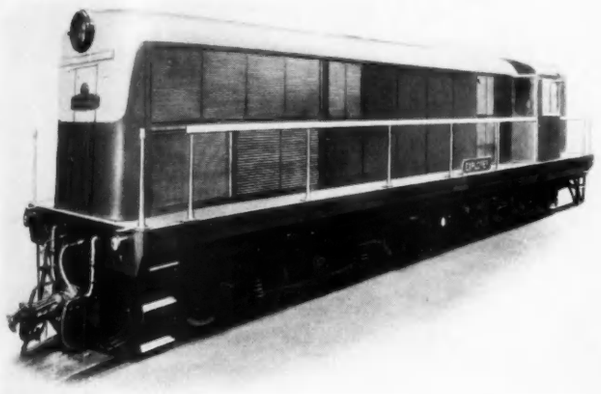
During the past few years there has been a steady decline in the export of locomotives of all types from the United Kingdom. It is in the hope of reversing this trend that the British Thomson-Houston Company Limited, Rugby, and Lister Blackstone Rail Traction Limited, Dursley, have jointly developed the 1,100 h.p. "Explorer" diesel electric mixed traffic locomotive—a versatile, comparatively low-cost engine designed primarily for reliability under varying climatic conditions.

The Explorer has been designed for use on the lighter type of railway in overseas territories where freight forms a large proportion of the total traffic. Such railways tend to operate heavy freight trains at medium speeds; and the small number of passenger trains are slow by European standards, generally due to limitations of the track itself. Many of these railways are of a track gauge smaller than the standard 4 ft 8½ in and all are restricted to light axle loads. Provision has to be made for operating at high ambient temperatures and also, at times, at high altitudes. By fixing the maximum engine output to 1,100 h.p. it will be possible to sustain the output at sea level in an ambient temperature of 120° F or up to an altitude of 4,000 ft at an ambient of 80°—85° F.

The locomotive is of the narrow hood type with a single cab located towards one end; this type has been adopted due to consideration of maintenance under conditions of high ambient temperature. The removable doors and roof sections provide maximum accessibility to all parts requiring regular inspection and maintenance. As a result of experience, this type of construction is now generally preferred by railways operating under tropical conditions. The principal particulars of the Explorer are given in the accompanying table.

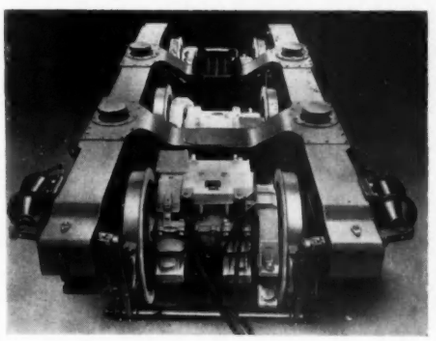
The principal sub-contractors for the mechanical parts are the Clayton Equipment Company Limited, Derby. Interesting features of the design are the use of deep castellated beams for the underframe, fabricated from standard sections and plates; and the bogies, which are of a design new to the United Kingdom.

Each bogie has two rubber cone pivots of the



The "Explorer" locomotive is designed for a wide variety of duties in overseas countries.

Bogie, complete with traction motors. Rubber cone pivots of the Alsthom type are used.



well-known Alsthom type, on which the body is carried. The pivots themselves are supported on the fixed bolsters on pads of rubber which allow side movement in shear. In addition the inner pivot assembly on each bogie can slide as a unit on manganese pads to allow the negotiation of tight curves. Four side bearers are provided with coil springs and manganese pads. Roller bearing axle boxes are provided. Each axle box is carried by two radius rods from the bogie frame; the radius rods are fitted with Silentbloc bushes at each end. Primary springing consists of underhung equalising beams and coil springs.

Both mechanical and electric dynamic braking systems are provided.

POWER EQUIPMENT

The diesel engine is a Lister Blackstone type ERS.12-T four-stroke exhaust turbo-charged rail traction unit having a continuous rating of 1,100 b.h.p. at a crankshaft speed of 800 r.p.m.; it has an idling speed of 350 r.p.m. Each of the twin banks of cylinders is similar to the standard range of Lister Blackstone Type ERS six-cylinder engines. The two lines of six cylinders are axially parallel and opposite to each other, there being two crankshafts carried in bearings both supported in a common steel fabricated bedplate, above which is mounted a cylinder housing.

The crankshafts are identical and are each fitted with a small flywheel. The drive is taken through hardened and ground spur gearwheels and a pinion mounted on the generator shaft which rotates at a speed of 1,320 r.p.m., corresponding to the engine speed of 800 r.p.m.

Principal Particulars of the Explorer Locomotive

Ratings—	
Engine total output to B.S. 2953: 1958 ..	1,100 h.p. at 800 r.p.m.
Input to generator for traction (average) ..	1,030 h.p.
Tractive effort, maximum	42,000 lb
Tractive effort at continuous rating of motors	24,000 lb
Maximum service speed	55 m.p.h.
Weight—	
Total per locomotive —minimum 72 tons	
Axle load —minimum 12 tons (can be increased to 14 tons if required)	
Leading Dimensions—	
Minimum gauge	39⅜ in (metre)
Maximum "	5 ft 6 in
Maximum length over headstocks ..	49 ft
Maximum overall height	12 ft 9 in*
Maximum width	9 ft 9 in*
Bogie wheelbase	12 ft
Total wheelbase	36 ft
Bogie pivot centres	30 ft
Wheel diameter	36½ in
Clearance between motor and rail ..	6½ in
Clearance between gear case and rail ..	5½ in
Minimum radius of curve	300 ft
* In certain cases these dimensions can be reduced	
Capacities—	
Fuel	500 gallons
Water	50 gallons
Sand	20 cu. ft
Equipment—	
Engine	Blackstone type ERS.12-T
Traction generator	BTH type RTB.14440
Auxiliary generator	BTH type RTB.7428
Traction motors	Six BTH type 138
Control	Single-cab double station (Multiple unit if required)
Brakes	Straight air on locomotive; automatic, air, or vacuum for train

Blackstone patented flexible couplings and Nodal dampers are interposed between the engines and generator driving gears and provide: (*a*) For smoothing out the variations in torque transmitted from the engine crankshaft and to prevent reversal of gearwheel tooth loading through the speed range of operation. (*b*) For introducing a high degree of flexibility and damping to eliminate any torsional oscillations between the two banks of cylinders.

Hydraulic damper units are bolted to the front end of the engine crankshafts, their purpose being to eliminate harmful torsional oscillations which might otherwise occur within each individual engine crankshaft system at some point in the working speed range. They operate on the positive oil displacement system.

If necessary, as an emergency measure, it is possible to uncouple one bank of cylinders from the drive and this permits the locomotive to operate at reduced power on the remaining bank.

The governor is the Blackstone standard four-weight type, duplicated and linked to actuate both lines of fuel pump control racks, thus maintaining a balance of power output from each bank of cylinders at all speeds and loads. The governor is fitted with a servo actuating gear for control from the locomotive cab. The engine is automatically stopped if the speed rises by more than 20 per cent above the normal engine speed of 800 r.p.m., or if the lubricating oil pressure falls below 10 lb per sq. in.

The main generator is a ten-pole machine which has been specially designed for the severe duties associated with traction work in conjunction with an internal combustion engine. Its continuous ratings to BS 173: 1941 temperature rises with Class "B" insulation are: 515 volts 1,310 amperes, 675 kW, 1,125 r.p.m.; 290 volts, 2,310 amperes, 670 kW, 1,125 r.p.m.

The auxiliary generator is built on the same shaft as the traction generator and follows the same general mechanical construction. It is an eight-pole, shunt-wound machine, suitable for working in conjunction with the automatic voltage regulator. Its continuous rating to B.S. 173: 1941 temperature rises with class "B" insulation is: 110 volts, 48 kW, 700/1,125 r.p.m.

The differential exciter, mounted on the auxiliary generator, is driven by V-belts from a pulley on an extension of the traction generator shaft. It is a four-pole machine with self and separate field windings, and a differential winding carrying the main traction current. The exciter operates in conjunction with the load control unit to regulate the load on the diesel engine.

The traction motors are of the box frame type and are arranged for axle suspension with a single reduction drive to the axle. The continuous rating to BS 173: 1941 temperature rises with Class "B" insulation is: 290 volts, 385 amperes, 440 r.p.m. Two motor-driven centrifugal blowers supply cooling air.

Two compressors, each having a capacity of 62 cu. ft swept volume, are mounted at the free end of the engine, each being directly coupled by shaft extension to one of the engine crankshafts. These operate at a normal pressure of 100 lb per sq. in and are connected to a common main reservoir. When vacuum braked trains are to be handled, two electrically driven exhausters are installed; each are of 60 cu. ft. per min displacement at normal speed and double this displacement when required to release the brakes.

CONTROL SCHEME

Engine starting is accomplished by motoring the engine using the main generator as a motor taking its power from the batteries. When the driver's master handle is moved to the "engine only" position, the engine run valve is energised, thus putting the fuel pumps under the control of the governor. On depressing the engine start pushbutton, the oil priming pump is started, flooding the engine bearings: a pressure switch connected to the oil system then completes the circuit to the starting contactors. After the engine has been started a relay in the auxiliary generator circuit serves to open the start contactors.

After selecting "forward" or "reverse" the power handle is advanced. This action connects the six traction motors in parallel to the main generator and provides weak excitation to the generator. Further movement of the driver's controller progressively increases excitation and increases the governed engine speed by means of pneumatic control. One step of traction motor field weakening is provided, this being automatically introduced when the locomotive reaches a pre-determined speed, dependent upon the throttle setting.

Load control equipment is provided so that, when running at full power, the generator excitation is automatically adjusted to maintain full load on the engine. Operation of the load control equipment is initiated when the engine governor demands more or less fuel than that corresponding to full load. The locomotive is arranged for multiple unit control and up to three locomotives can be operated together from one driving position.

Dynamic braking is achieved by causing the traction motors to act as generators, the current so generated being dissipated in resistor banks. For convenience of control, the traction motors are treated as separately excited generators and a fixed value of resistance is connected across the armature of each motor. The braking effort is varied by adjustment of the motor field strength. The brake resistors are made in the form of a grid of special high resistance steel strip and are arranged for forced ventilation.

The main control equipment comprises the driver's controllers and a cubicle in which the main control gear is mounted, situated in the body of the locomotive. There is a power controller and a dynamic braking controller at each driving position. Each comprises a cam-operated multipoint switch mounted in a sheet-steel cabinet.

The control cubicle containing the traction motor contactors, field shunting contactors, reverser, starting contactors, voltage regulator, etc., is constructed so that it can be mounted in the body of the locomotive separate from the driver's cab.

Research and Development

ESCAPE

from a Submerged Aircraft

Four years ago a Fleet Air Arm pilot managed to free himself from a submerged and rapidly sinking aircraft by using his standard Martin-Baker ejection seat. At the time this was thought to be a lucky escape and a great number of trials have since been made to investigate the technique in the hope that it would lead to the development of a standard ejection seat which could be used safely in both sea and air. At the request of the Admiralty the investigation was carried out by the Royal Air Force Institute of Aviation Medicine.

The technical difficulties of ejection under water were soon overcome, but the physiological problems involved were complex and required a large number of experiments and trials before completion. The team which carried out this work consisted of three naval medical officers and a crew of clearance divers.

Preliminary experiments were made on a life-sized dummy, nicknamed Neptune, which was filled with small balloons to give it the same weight, displacement, and buoyancy as an average man. Instruments were attached to the dummy to record the pressures at the vital points. The acceleration of the seat and the dummy were also measured.

The instrument used to measure acceleration was a Lancelec variable inductance transducer, feeding through an a.c. bridge amplifier into a galvonometer recorder. Pressure readings on the dummy were taken with a modification of this instrument. The higher pressures, close to the separation point of the gun, were measured with a 2,000 lb per sq. in barrel type resistance pressure gauge.

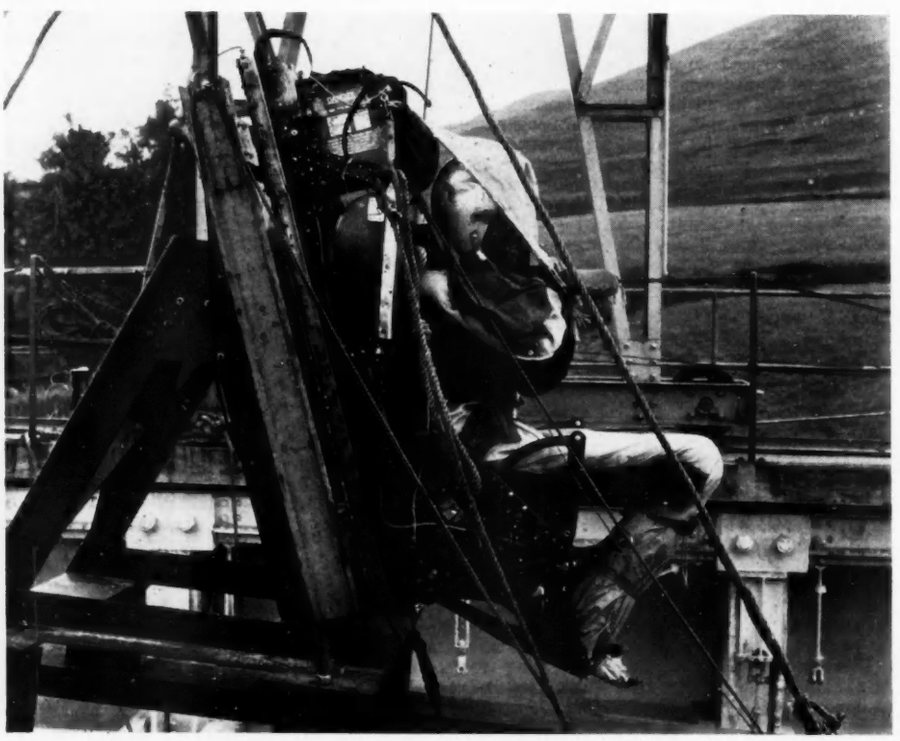
To measure the maximum velocity of the seat the fixed supporting frame was fitted with a series of equally spaced coils, over which the seat moved a small permanent magnet. The output of the coils was then recorded on a cathode-ray oscillograph with an attached camera. The integrated accelerometer readings could be used as a check on the value obtained by this method.

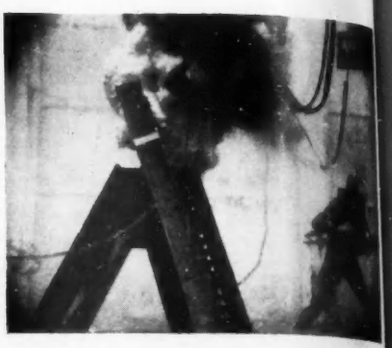
Measurements showed that the dummy was discharged into the water with a propulsion rate of about 35 ft per second. This would correspond to the drag on the body when thrown into the air at 35,000 ft at a speed of Mach 1. During these trials the maximum peak acceleration force was found to be 9*g* and the mean acceleration force 6*g*. These are within the limits accepted for normal aircraft ejections.

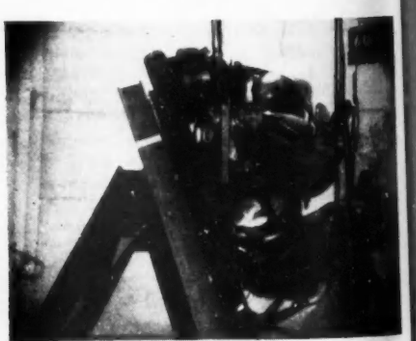
In attempting to shoot a man upwards through water at high speed, the problem arises of the effect of pressure change on the respiratory system. If this is unchecked the rapid reduction of pressure could rupture the man's lungs. The recommended remedy for this is for the pilot to breathe out before firing his seat. However, since this could easily be forgotten, it is fortunate that the back-pressure to the firing blast (much higher in water than in air) tends to strike the man forcibly in the chest and abdomen, thus making him gasp and expel the air from his lungs. For this reason, since it is not harmful, no attempt has been made to cushion the blast thrust.

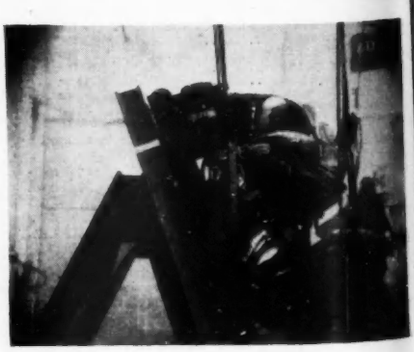
Human tests were made to check the tolerance

Dummy in ejection seat, mounted on frame, ready for lowering into the Glen Fruin Tank.









Testing the underwater ejection seat at the Admiralty Research Establishment, Glen Fruin. The sequence begins at the foot of the page.

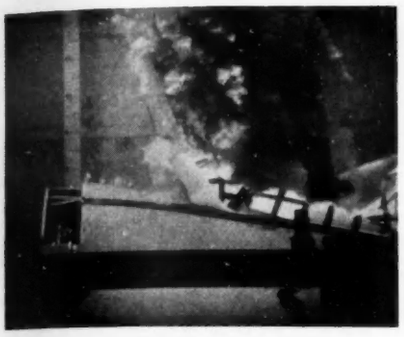
(*Official Admiralty photographs.*)

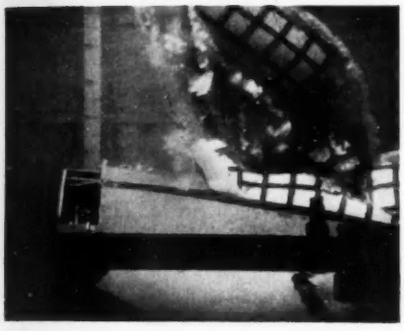
of the body to drag and high velocity travel through water. At first an attempt was made to bring a man up from the bottom of a lake in a bosun's chair towed by a speedboat. However, the drag was so great that the boat could not move. Later, a trapeze was lowered to the bottom of the lake and the other end attached to a powerful sports car on the shore. A diver held down the subject, who firmly gripped the trapeze. The car then accelerated rapidly to 30 m.p.h., whisking the subject to the surface at speeds up to 40 ft per second.

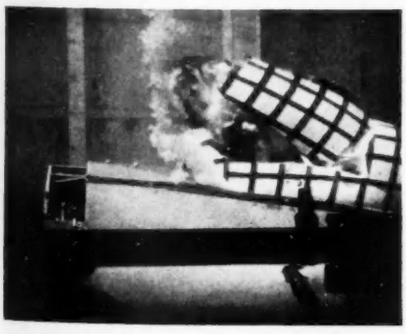
Human trials also included ejection escapes from a Seahawk cockpit 40 ft under water. In these tests it was found that the ejection seat would carry the pilot up through 14 ft-17 ft of water before automatically releasing him. At this stage the pilot must inflate his "Mae West" and rid himself of his parachute harness in order to float freely to the surface.

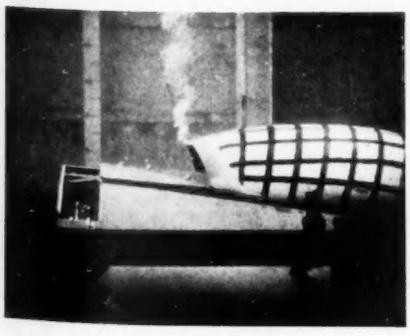
Difficulty in jettisoning the canopy was experienced and experiments were carried out on the dummy to see if it were possible to shoot a pilot straight through the canopy. This proved to be successful and may be adopted as standard procedure, whenever necessary, for pilots flying aircraft with moulded plastic canopies. For aircraft with canopies that cannot be crashed through in this manner, various other mechanisms have been designed to minimise the possibility of a pilot being trapped in his cockpit after an accident.

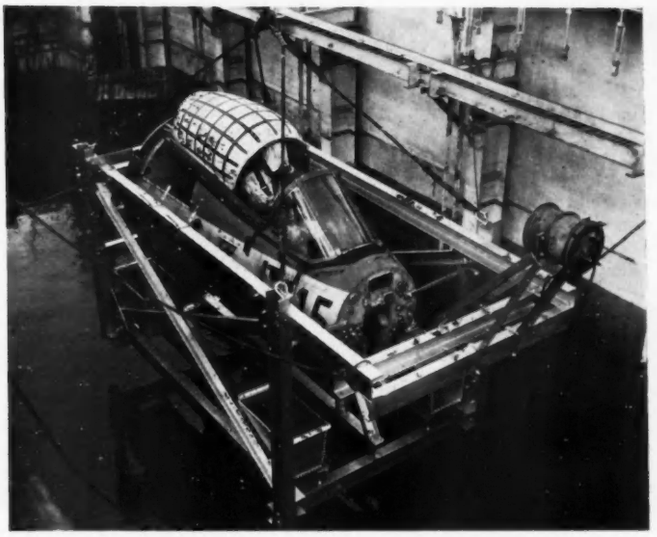
Underwater ejection of seat and dummy. This sequence starts at the bottom of the page.











Cockpit section of fuselage, containing ejection seat and dummy, mounted in the frame for lowering into the water. The canopy is partly removed.

CHOOSING A PROPELLENT

Chemical Fuels for Rocket Motors

High-energy propellents were compared in a lecture given to the British Interplanetary Society on 7 February by Mr. F. Fitzgerald of the department of chemistry in the College of Technology, Birmingham. The lecturer discussed the properties of the chemical elements, and pointed out that the greatest performance must come from propellents giving exhaust products of very low molecular weight. Of the fuels, hydrogen was outstanding, and gave the highest available specific impulse with fluorine or perhaps ozone, but its low specific gravity as a liquid (0·07) and low evaporation temperature (20° K) made its use in rocket vehicles difficult. The lecturer said that most writers dismissed hydrogen summarily on account of its low density, but he made a strong plea that its use should be investigated thoroughly. He pointed out that it could be pumped fairly readily, and did not cause corrosion: the heat transfer properties should be good, and many common metals could be used in contact with it without danger of embrittlement.

The other light elements which had potentialities as fuels were beryllium, lithium, sodium, boron, magnesium and aluminium. All of these are solid at room temperature, although lithium and sodium could perhaps be melted and pumped in the rocket. The others would have to be dispersed as slurries in kerosine or some similar liquid fuel, which would act as a diluent on the rocket performance. Slurries are difficult to make with uniform characteristics from batch to batch, and there is always a hazard that they may deposit metal in rocket coolant passages and block them.

Hydrides of boron and nitrogen can be obtained which are liquids at room temperature, the boranes (pentaborane, for example) giving high performance with oxygen. They are toxic, however, and are expensive to make although boron (as borax) is readily available. The nitrogen hydrides, ammonia and hydrazine, do not give very high performance, due to the diluent effect of the nitrogen. Hydrazine decomposes readily and is very toxic.

The best oxidants are fluorine and oxygen, with the allotropic form of oxygen, ozone (O_3), as a possible provider of high performance if it can be made non-detonable. Fuorine and hydrogen give a very high specific impulse without too high combustion temperatures, but fluorine, even as a liquid, is highly corrosive, and reacts violently with most substances. It is highly toxic. Mixtures of fluorine and oxygen, and of oxygen and ozone, may be used, since a 30 per cent solution of ozone in oxygen does not detonate and gives a useful increase in performance, while fluorine-oxygen allows hydrocarbons to be used as fuels without the formation of soot or of high molecular weight fluorocarbon exhaust products.

Mr. Fitzgerald supported the widely held view that free-radical propellents, if used by storing radicals in tanks and allowing them to combine in a rocket chamber as required, would not be practicable; even when stored at very low temperatures there would be an unacceptable release of heat energy by recombination. The low molecular weight of an exhaust jet from a dissociated-hydrogen rocket, however, indicates that very high performance could be obtained, though there would be some loss due to the recombination being kept from going to completion by the high temperatures reached. The best way of using radicals in a rocket is to produce them in a nuclear heating plant in the vehicle and to let them recombine immediately in a nozzle. Nuclear energy has of course other applications in propulsion, for example in accelerating ions and plasma and ultimately in producing photon drive systems, and it may be that activity in this sphere may make the chemist's work unnecessary in years to come.

Construction

UNDERPINNING WITHOUT PROPS

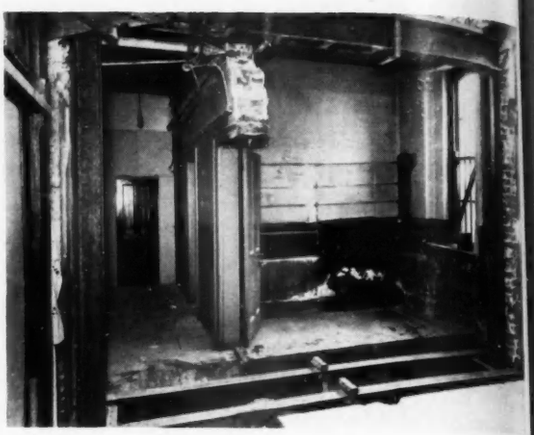
A stressed steel girder which avoids the use of needles or props in underpinning operations has been developed by Joseph Westwood and Company. The girder is covered by a provisional patent.

The girder is made in short sections that can be inserted under self-supporting lengths of the wall. When the full run of the girder is in position the separate sections are joined together with high tensile bolts. By using suitable packings between the wall and the girder sections, and introducing a stress into the girder later, the latter can be made to take a predetermined share of the load. A typical application of the Westwood girder is shown in the accompanying drawing and photographs which illustrate making a considerable opening in a brick partition wall.

When the girder is erected the joints are left slightly open on the tension side, so that the girder assumes a curvature which will be, in general, its calculated deflection under load. The girder is then packed solid to the wall or floor imparting the load, and the bolts in the joints systemmatically tightened using a torque-meter. The action of tightening these bolts closes the joints and stresses the tension flange of the girder, thus enabling the girder to take up its load without deflecting. The shear on the joint is resisted by friction between the adjoining faces of the connecting details and is amply provided by the tension in the bolts. Because no reliance is placed on bolt bearings, clearance holes are used in the connecting plates and no difficulties are experienced when inserting the bolts.

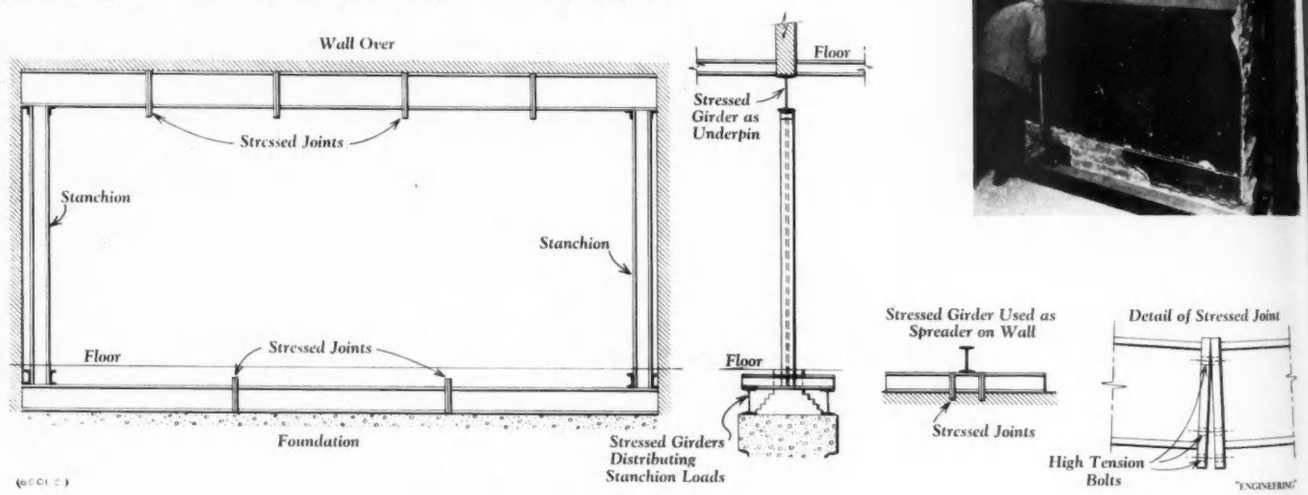
Calculations for the size of the steel girder itself are made in the usual way, the connection detail being such that the girder section is not weakened by drilling holes.

The girder was originally developed by Mr. M. F. Palmer, joint managing director of Joseph Westwood and Company Limited; the address of the company is Napier Yard, Millwall, London, E14.



Two stages in the construction of a portal frame which permitted the demolition of a brick partition wall. The lower picture shows the girder sections packed so that loads continue to be carried by the partition until the completed girder has been stressed.

Typical use of the Westwood stressed steel girder, with detail of the joint.



GIRDER BRIDGE STANDARD

Revised BS 153

The British Standard for steel girder bridges (BS153) has been extensively revised and regrouped for issue as two separate booklets. The first booklet includes Part 1 of the standard and deals with materials, workmanship and protection against atmospheric corrosion; Part 2 covers weighing, shipping and erection. The second publication contains Part 3B, stresses, and Part 4, design and construction. It is hoped eventually to incorporate in the two publications Part 3A, loads, which at present is issued separately.

The specification is intended primarily to apply to the superstructure of simply-supported steel bridges of spans up to 300 ft. Where appropriate, however, the specification may be adopted for larger spans or other types of steel bridges, though care must then be taken to make adequate allowance for the fixity of the supports, continuity or other indeterminate and special conditions such as may apply to opening bridges.

The new Part 1 refers to the use of steels of the later British Standards, namely: BS 548 and BS 968 "High Tensile Structural Steels"; BS 2762 "Notch Ductile Steels (Class B)"; BS 309 "Malleable Cast Iron"; and BS 2789 "Spheroidal or Modular Cast Iron." The section on anti-corrosion methods includes much new information on surface cleaning processes and metallisation by spraying.

Copies of these publications may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London W1. Prices: Parts 1 and 2, 6*s*; Parts 3B and 4, 15*s*. (Postage will be charged extra to non-subscribers.)

MODELS AND FILMS

Many civil engineering contractors have films and models which can be lent to schools, universities and others interested in construction work at home and abroad. An up-to-date list of what is available has been prepared and copies may be obtained, free of charge, from the Federation of Civil Engineering Contractors, Romney House, Tufton Street, Westminster, SW1.

The list is subdivided under sub-headings such as docks and harbours, coal, hydro-electric schemes and careers. A brief description is given of each film together with projection details. In the case of models the description is accompanied by facts concerning the scale and size. The name and address of the person to approach in each case is also given in the list which contains about 90 entries.

MEETINGS AND PAPERS

Association of Supervising Electrical Engineers

LONDON
"Wired Television Systems: Installation and Maintenance Problems," by L. A. Isaacson. West London Branch. Windsor Castle Hotel, 134 King Street, Hammersmith, W6. Tues., 3 Mar., 7.30 p.m.

BOLTON
"Miniature Circuit-Breakers," by J. A. Robbins. Bolton Branch. Railway Hotel, Trinity Street, Bolton. Mon., 2 Mar, 7.45 p.m.

British Institution of Radio Engineers

MANCHESTER
"Closed-Circuit Television Equipment," by R. E. Blythe. North Western Section. College of Technology, Sackville Street, Manchester 1. Thurs., 5 Mar., 6.30 p.m.

British Interplanetary Society

LONDON
"Radio Communication with a Space Probe," by Dr. W. T. Blackband. Caxton Hall, off Victoria Street, SW1. Sat., 7 Mar., 6 p.m.

Chemical Society

BIRMINGHAM
"X-Ray Analytical Evidence on the Exact Conformation of Molecules," by Dr. Dorothy M. Hodgkin. Birmingham Branch. Chemistry Department, The University, Birmingham. Fri., 6 Mar., 4.30 p.m.

BRISTOL
"Some Aspects of Modern Refinery Operations," by D. T. Leahy. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., 5 Mar., 6.30 p.m.

HULL
"Stability of Metal Complexes," by Dr. H. M. N. H. Irving. Hull Branch. Organic Chemistry Lecture Theatre, The University, Hull. Thurs., 5 Mar., 6 p.m.

Engineers' Guild

EDINBURGH
"Bookmaking and Book Selling," by J. Thin. Luncheon Meeting. East of Scotland Branch. Scottish Liberal Club, 109 Princes Street, Edinburgh. Mon., 2 Mar., 12.45 for 1 p.m.

Helicopter Association

LONDON
"The Place of the Helicopter in a Modern Army," by Lieut.-Colonel P. W. Mead. Royal Aeronautical Society, 4 Hamilton Place, W1. Fri., 6 Mar., 6 p.m.

Illuminating Engineering Society

EDINBURGH
"Lighting and Safety in Building Operations and Works of Engineering Construction," by J. Gordon Scott. Edinburgh Centre. YMCA, 14 South St. Andrew Street, Edinburgh. Wed., 4 Mar., 6.30 p.m.

GLASGOW
"Lighting and Safety in Building Operations and Works of Engineering Construction," by J. Gordon Scott. Glasgow Centre. British Lighting Council, 29 St. Vincent Place, Glasgow, C1. Thurs., 5 Mar., 6.30 p.m.

NOTTINGHAM
"Lighting Installations at the Nottingham and District Technical College," by P. A. Moore. Nottingham Centre. Electricity Service Centre, Nottingham. Thurs., 5 Mar., 6 p.m.

Institute of Marine Engineers

LONDON
"Marine Lubrication," by G. H. Clark. Student Lecture. Mon., 2 Mar., 6.30 p.m.*
"Some Metallurgical Features of Nuclear Reactors," by Dr. H. M. Finniston. Joint Nuclear Marine Propulsion Panel. Tues., 3 Mar., 5.30 p.m.*

BIRMINGHAM
"Energy from the Atom," by Professor C. F. Powell. West Midlands Section. Birmingham and Midland Institute, Paradise Street, Birmingham. Fri., 6 Mar., 7 p.m.

LIVERPOOL
"Welding in Marine Engineering," by J. A. Dorrat. Merseyside and North Western Section. Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool. Mon., 2 Mar., 6 p.m.

Institute of Metals

LONDON
"High-Temperature Brazing," by A. Cibula. London Local Section. Thurs., 5 Mar., 6.30 p.m.*

OXFORD
"Metallurgical Applications of the Electron Microscope," by Dr. J. Nutting. Oxford Local Section. Cadena Café, Cornmarket Street, Oxford. Tues., 3 Mar., 7 p.m.

SWANSEA
"Effects of Vacancies and Other Point Defects in Metals," by Professor A. H. Cottrell. South Wales Local Section. University College, Singleton Park, Swansea. Tues., 3 Mar., 6.30 p.m.*

Institute of Petroleum

LONDON
"Looking Ahead: On the Threshold of Our Second Century," by H. E. Snow. Wed., 4 Mar., 5.30 p.m.*

Institute of Refrigeration

LONDON
"Application of Refrigeration to Horticultural Production in the Netherlands," by Ir. T. van Heile. Institute of Marine Engineers, 76 Mark Lane, EC3. Thurs., 5 Mar., 5.30 p.m.*

Institution of Chemical Engineers

BIRMINGHAM
"Reynolds's Analogy and Mass Transfer," by Professor F. H. Garner, V. G. Jenson and R. B. Keey. Midlands Branch. Birmingham College of Technology, Gosta Green, Birmingham. Wed., 4 Mar., 6.30 p.m.

Institution of Civil Engineers

LONDON
"Development in Overhead Electrification of Railways as it Affects the Civil Engineer," by R. E. Sadler. Tues., 3 Mar., 5.30 p.m.*

MANCHESTER
"Investigations of Navigation and Bridging Problems of the River Dee," by Professor J. A. L. Matheson. North Western Association. Engineers' Club, Albert Square, Manchester. Thurs., 5 Mar., 6.30 p.m.

Institution of Electrical Engineers

LONDON
"Influence of Consumers' Load/Consumption Characteristics on Metering Practice," by L. B. S. Golds. Measurement and Control Section. Tues., 3 Mar., 5.30 p.m.*
"Reliability and Life of Impregnated Paper Capacitors," by J. P. Pitts. Thurs., 5 Mar., 5.30 p.m.*
Discussions on "Potted Histories of Instruments Designed for Medical Purposes," opened by H. S. Wolff; and "Co-ordination of Research in Medical Electronics," opened by Dr. R. G. Willison. Fri., 6 Mar., 6 p.m.*

BARNSLEY
"The Deltic Locomotive," by C. M. Cock. North Midland Centre. Town Hall, Barnsley. Tues., 3 Mar., 7 p.m.

BELFAST
Faraday Lecture on "Automation," by Dr. H. A. Thomas. Northern Ireland Centre. Sir William Whitla Hall, Queen's University, Stranmillis Road, Belfast. Tues., 3 Mar., 7.30 p.m.

BIRMINGHAM
Brains Trust on "The European Common Market and Its Effect on the Electrical Engineering Industry." South Midland Centre. College of Technology, Gosta Green, Birmingham. Mon., 2 Mar., 6 p.m.*
Discussion on "Nuclear Technology and the Electrical Engineer," opened by Dr. J. Walker. South Midland Centre College of Technology, Gosta Green, Birmingham. Thurs., 5 Mar., 6.15 p.m.*

EDINBURGH
"Design of the 330 kV Transmission System for Rhodesia," by F. C. Winfield, T. W. Wilcox and G. Lyon. South East Scotland Sub-centre. Carlton Hotel, North Bridge, Edinburgh. Tues., 3 Mar., 7 p.m.

LIVERPOOL
First Hunter Memorial Lecture on "P. V. Hunter: Electrical Engineering in Our Time," by C. O. Boyse. Mersey and North Wales Centre. Royal Institution, Colquitt Street, Liverpool. Mon., 2 Mar., 6.30 p.m.

LOUGHBOROUGH
"Small Squirrel Cage Motors," by A. J. Holland; and "Sub-Stations for the Super Grid," by R. W. Hughes. East Midland Centre. College of Further Education, Loughborough. Tues., 3 Mar., 6.30 p.m.*

MANCHESTER
"Subscriber Trunk Dialling," by D. A. Barron. North Western Centre. Engineers' Club, Albert Square, Manchester. Tues., 3 Mar., 6.15 p.m.

Institution of Engineering Inspection

BRISTOL
Discussion on "Vacuum Leak Detection." South Western Branch. Grand Hotel, Broad Street, Bristol 1. Tues., 3 Mar., 7.30 p.m.

COVENTRY
"Magnetic and Penetrant Methods of Non-Destructive Testing," by H. R. Bezer. Coventry Branch. Coventry Technical College, Coventry. Tues., 3 Mar., 7.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Recent Developments in Panel Heating," by H. H. Bruce. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, SW1. Wed., 4 Mar., 6 p.m.*

NEWCASTLE UPON TYNE
Discussion on "Skirting Heating." North East Coast Branch. Neville Hall, Westgate Road, Newcastle upon Tyne. Tues., 3 Mar., 6 p.m.

NOTTINGHAM
Problems Evening. East Midland Branch. College of Arts and Crafts, Waverley Street, Nottingham. Wed., 4 Mar., 6.30 p.m.

Institution of Highway Engineers

LONDON
"Oxford Eastern Bypass," with films, by K. Summerfield. Institution of Structural Engineers, 11 Upper Belgrave Street, SW1. Fri., 6 Mar., 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "Engineering Standards: Development and Use." Industrial Administration and Engineering Production Group. Thurs., 5 Mar., 6 p.m.*
"Approximate Equations for the Properties of Superheated Steam," by Professor J. H. Horlock. Meeting in conjunction with the Steam Group. Fri., 6 Mar., 6 p.m.*

GLASGOW
"Natural Circulation Investigations on an Experimental Two-Tube Boiler," by A. M. Laird, Professor A. W. Scott and Professor A. S. T. Thomson. Scottish Branch. Royal College of Science and Technology, Glasgow. Thurs., 5 Mar., 7.30 p.m.

NEWCASTLE UPON TYNE
Thomas Lowe Gray Lecture: "Marine Refrigeration," by H. R. Howells. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 2 Mar., 6 p.m.

Institution of Plant Engineers

LEICESTER
"Lubrication in Industry: a Critical Survey," by T. Collins. Leicester Branch. Bell Hotel, Leicester. Wed., 4 Mar 7 p.m.

ROCHESTER
Annual General Meeting. Kent Branch. King's Head Hote High Street, Rochester. Wed., 4 Mar., 7 p.m.

Institution of Production Engineers

NOTTINGHAM
Annual General Meeting. Nottingham Section. Reform Club, Victoria Street, Nottingham. Wed., 4 Mar., 7 p.m.

Institution of Public Health Engineers

LONDON
Discussion on "Control of Industrial Wastes," by W. Fillingham Brown. Caxton Hall, off Victoria Street, SW1. Mon., 2 Mar., 6 p.m.

Institution of Railway Signal Engineers

YORK
Film and Discussion on "Cable Laying Technique." York Branch. Signalling School, Toft Green, York. Tues., 3 Mar., 5.30 p.m.*

Institution of Structural Engineers

BELFAST
"Modern Methods of Timber Engineering," by H. Tottenham Northern Ireland Branch. College of Technology, Belfast. Tues., 3 Mar., 6.45 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., 6 Mar., 7 p.m.*

Leeds Metallurgical Society

LEEDS
"Metallurgical Applications of High-Resolution Microscopy," by Dr. J. Nutting. Chemistry Wing, The University, Leeds 2. Thurs., 5 Mar., 7.15 p.m.

Prestressed Concrete Development Group

LONDON
"How Can the Advantages of Prestressed Concrete Best be Utilised?" by Professor H. Rüsch (of the Institution of Technology, Münich). Royal Commonwealth Society, Craven Street, WC2. Wed., 4 Mar., 6 p.m.*

Reinforced Concrete Association

MANCHESTER
"The Architectural Expression of Structural Concrete," by W. A. Gibbon. North Western Branch. College of Technology, Sackville Street, Manchester. Mon., 2 Mar., 6.45 p.m.*

Royal Aeronautical Society

FELTHAM
"Sir Richard Fairey: an Appreciation," by G. W. Hall. London Airport Branch. Feltham Hotel, Feltham. Thurs., 5 Mar., 6 p.m.

Royal Institution

LONDON
"Metal Surfaces," by Dr. Ronald King. Fri., 6 Mar., 9 p.m.

Royal Meteorological Society

LONDON
"Our Changing Climate: Past and Present," by H. H. Lamb. Wed., 4 Mar., 5 p.m.*

Royal Society Health

HUDDERSFIELD
Various short papers. Town Hall, Huddersfield. Thurs., 5 Mar., 10 a.m.

Sheffield Metallurgical Association

SHEFFIELD
"The Competitive Position of the British Steel Industry," by E. T. Sara. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 3 Mar., 7 p.m.

Society of Chemical Industry

LONDON
Three papers on "The Diagnosis of the Causes of Corrosion Failures." Corrosion Group. Wed., 4 Mar., 6.30 p.m.

Society of Engineers

LONDON
"Some Experiences of River Control in Africa," by R. G. T. Lane. Geological Society, Burlington House, Piccadilly, W1. Mon., 2 Mar., 5.30 p.m.*

Society of Instrument Technology

LONDON
Symposium on "The Use of Data Recorded on Industrial Plant." Data Processing Section. Manson House, Portland Place, W1. Thurs., 5 Mar., 6 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough Gardens, London, SW1. (TATe Gallery 9371.)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675.)
Engineers' Guild, 78 Buckingham Gate, London, SW1. (ABBey 7315.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, SW1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493.)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291.)
Institute of Petroleum, 61 New Cavendish Street, London, W1. (LANgham 3583.)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, EC4. (CENtral 4694.)
Institution of Chemical Engineers, 16 Belgrave Square, London, SW1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (TEMple Bar 7676.)
Institution of Engineering Inspection, 28 Victoria Street, London, SW1. (ABBey 3794.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria Street, London, SW1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476.)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469.)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria Street, London, SW1. (VICtoria 3017.)
Institution of Railway Signal Engineers. Apply to Mr. R. L. Weedon, 222 Marylebone Road, London, NW1. (AMBassador 7711.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Prestressed Concrete Development Group, Terminal House, Grosvenor Gardens, London, SW1. (BELgravia 6641.)
Reinforced Concrete Association, 94-98 Petty France, London, SW1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle Street, London, W1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, SW7. (KENsington 0730.)
Royal Society of Health, 90 Buckingham Palace Road, London, SW1. (SLOane 5134.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865.)
Society of Chemical Industry, 14 Belgrave Square, London, SW1. (BELgravia 3681.)
Society of Engineers, Abbey House, Victoria Street, London, SW1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251.)

Book Reviews

ADESTE FIDELIS

High Quality Sound Reproduction. By JAMES MOIR. *Chapman and Hall Limited, 37 Essex Street, London, WC2.* (70*s*)

Sound reproduction in public places and in the home has long been a regular feature of modern life, but for economic reasons, little of this comes into the high-quality category. In domestic sound reproducing equipment in particular, the average standard of quality is extremely poor, and there has always been a minority of individuals who are actively interested in achieving something better. To the technically minded, the engineering problems involved in obtaining high-quality sound reproduction in the home offer so fascinating a field for study and debate that in fact the pursuit of " hi-fi " has in recent years become a cult, whose manifestations provide as much material for the psychologist as for the technologist. It must in fairness be said, however, that among the high-quality enthusiasts are many professional engineers and knowledgeable amateurs with a serious interest in electro-acoustics extending far beyond the domestic reproducing equipment with which they are directly concerned. There is thus a demand for up-to-date information, presented at something less than specialist level, on such subjects as the acoustic design of studios and concert halls and the techniques of film recording, together with the construction of microphones and other equipment involved in originating a broadcast or recorded sound programme. Mr. Moir's comprehensive volume represents an attempt to fill this need.

High-Quality Sound Reproduction consists of a re-presentation, in the light of the author's long experience in both professional and amateur capacities, of the subject usually known as " applied acoustics," with the addition of other material which is not normally found under this heading but is likely to be of interest to the amateur experimenter. About two-thirds of the book is concerned with various aspects of sound, including speech and hearing, the construction and operation of microphones and loudspeakers, recording on disc, film and tape, architectural acoustics, and stereophonic reproduction. The rest of the space is devoted to a detailed discussion of amplifier and circuit technique, in which, for example, the principles and practice of negative feedback, of output transformers and of power supply rectifiers, each receive a chapter to themselves. The treatment adopted varies with the different parts of the subject, more detailed attention being given to matters, such as the design of loudspeaker cabinets, with which the amateur is likely to be practically involved. The presentation is more descriptive in character than that of a standard textbook, and requires of the reader no more than an elementary knowledge of engineering mathematics. A short glossary of acoustical terms and definitions is provided for the benefit of newcomers to the field. For some reason, not clear, this glossary is based on an American Standard of 1951 rather than on the corresponding British Standard of 1955; however, in spite of the author's close connection with the film industry, the book does not exhibit the heavy American bias so often found in works on electro-acoustics.

To cover such a wide field in a single volume is a formidable task. Success in such an undertaking depends not so much on an encyclopaedic knowledge as on skill in selecting representative subject matter and in so presenting it that, even with a superficial treatment, the essentials are preserved. Judged from this standpoint, the book is somewhat uneven in quality. The author is at his best when writing from his personal experience; when it comes to interpreting the literature, his touch is less sure, and some of his simplified descriptions might tempt an unwary student into unwarranted generalisations.

Each chapter of the book is supplemented with a number of references to the literature as suggestions for further study. These references are confined for the most part to such British or American publications as are readily accessible through technical libraries, and the reader should be warned not to ignore the important contributions to the art which have been made and continue to be made on the Continent.

Specialists will inevitably find plenty to quarrel with in a work of this kind; however, *High-Quality Sound Reproduction* should be of value to professional engineers with an amateur interest in electro-acoustics, and in particular to those who are prepared to regard it as the beginning rather than the end of their studies.

D. E. L. SHORTER

MATHEMATICS OF TWIST

Torsiontheorie. By CONSTANTIN WEBER and WILHELM GÜNTHER. *Friedr. Vieweg and Sohn, 20b Braunschweig, Burgplatz 1, Germany.* (38 *DM*)

If one asks a mathematician about the problem of the uniform torsion of an elastic prism, he will reply that it was solved by St. Venant about a century ago; and so it was. All that is needed to obtain the complete engineering picture is the numerical solution of a straightforward partial differential equation. That, of course, is the snag. In the book under review, Professor Weber and Dr. Günther have collected most of the important methods of solution and have set them out in commendably lucid form.

The book is written in the first place for applied mathematicians, but it is an excellent treatise for the engineer who likes to know what he is doing and is not content to apply formulae blindly. It gives in appendices the basic theory of elasticity and of harmonic functions and conformal mapping and it is most unlikely that anyone interested in torsion theory will lack the background needed to make a start. From these foundations the theory is built up clearly and in detail. Starting with basic theory the work goes on to Prandtl's membrane analogy and then settles down to solutions using complex variables. Most attention is given to conformal transformations and a wide variety of cross-sections is considered.

As a treatise on the theory of torsion the book is first class; but as a reference book for engineers it suffers from two deficiencies. First, the most useful of all methods, namely, " relaxation " is omitted. This is regrettable since it can be used for all practical shapes of cross-section by people whose knowledge of mathematics is scanty. Second, the book has no index and only a scanty bibliography. If it is intended that the book should appeal to engineers, as the authors say it is, these defects should be remedied in the second edition; and it would be of considerable value if, in addition, a list of known solutions could be included.

S. J. MCMINN

MOTION AND MEASUREMENT

Engineered Work Measurement. By DELMAR W. KARGER and FRANKLIN H. BAYHA. *The Industrial Press, 93 Worth Street, New York 13, USA.* ($13·75); and *Machinery Publishing Company Limited, National House, 21 West Street, Brighton,1.* (110*s*)

As a title *Engineered Work Measurement* does not convey any clear meaning to the British reader, however well versed he may be in work study terminology. Some clarification, however, is given in the subtitle " The principles, data and techniques of methods-time measurement, modern time and motion study and related applications engineering data," which does adequately summarise the contents. But nowhere can any explanation be found for the coining of such an expression as "engineered work measurement."

Approximately half of the book is devoted to a lucid and comprehensive description of methods-time measurement (commonly known as MTM), which is one of the group of work measurement techniques known collectively in Britain as predetermined motion time systems or, in short, PMTS. For those unacquainted with the term, the BSI draft definition may be quoted. " A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance." The originators' definition of MTM, as given in the book, agrees substantially with this.

The other half of the book deals with time study principles and procedures on lines fairly representative of good American practice. It is unfortunate, and indeed incorrect, that the system of relating observed times to standard times, generally known in both Britain and America as levelling, should have been referred to as performance rating, which has a specific meaning of its own in work study terminology.

It is that part of the book explaining MTM that will be of most interest and practical use to the British reader. In view of the increasing recognition of the possibilities of predetermined motion time systems, work study practitioners will certainly be well advised to digest the very clear explanation, amounting to over three hundred pages, of the MTM technique.

Methods-time measurement was developed by H. B. Maynard, G. J. Stegemerten, and J. L. Schwab, all consultants with the Methods Engineering Council of Pittsburg, Pennsylvania, and their data has been made available for practitioners. This is not to say, of course, that training and experience of its practical application is an unnecessary preliminary to the use of the data. But an experienced work study practitioner can employ the information not only to check the results of his time studies on the shop floor but also to assess performance times for planning and estimating purposes with some accuracy before new lines are launched into production. Whether MTM data can be used for the determination of incentive standards will depend upon the attitude of the trade unions who very possibly will insist upon verification by actual timings.

The inclusion of practical questions and problems on the application of MTM basic motions and data is a most commendable feature of the book. It is to be hoped that the uninitiated will be able to obtain correct answers from some MTM trained friend or colleague

On account of its American terminology and unbalanced contents, it cannot be recommended as a students' textbook for such examinations as A.M.I.Mech.E., Higher National endorsement, Work Study Society, and British Institute of Management. But there is much that could be used by teachers, particularly in the part dealing with MTM.

H. E. KEARSEY

CALLING LONG DISTANCE

Voice Across the Sea. By ARTHUR C. CLARKE. *Frederick Muller Limited, Ludgate House, 110 Fleet Street, London, EC4* (18*s*)

The miracle of instantaneous correspondence between points, previously weeks, or even months apart, has lost some of its power to astonish us after a hundred years and it requires some imagination to appreciate the difficulties which confronted the pioneers of transoceanic telegraphy in the middle of the last century. *Voice Across the Sea* is a history of telegraphy during this hundred years, very informative and readable and without too much technical information for the lay reader. As with all stories of scientific achievement, the most surprising feature is the speed of development which followed the first uncertain steps.

On the question of rapid development Mr. Clarke does rather less than justice to his own country and it is difficult to appreciate how a history of the subject could be written without mentioning the Eastern Telegraph and its associated companies.

The first successful Atlantic cable was laid in 1866 and this enterprising English group laid its first cable from Cornwall to Lisbon in 1870. By the following year it had extended its system to Gibraltar, Malta, Egypt, India, Malaya, China, Sumatra and Australia (at 9*s* 4*d* a word). Within about twenty years they operated a vastly greater cable system than exists today, serving almost every country in the world.

Naturally enough, the main story in the book is the drama of the Atlantic cable, a drama in which the characters are men of such fanatical determination that no dramatist would dare to invent them. Any fates that were conspiring against these men in their endeavours must have been irritated at the way in which they recovered from each staggering set-back, and pigeon-holed every misfortune to be used as experience for the next time.

The book traces the development of radio to its present state and the eventual reversion to cables—cables of a very different type, of course—and concludes with a jump into the future, when radio will come into its own again. The use of satellites may seem rather imaginative to many people but considering what has happened in the first hundred years of telegraphy it would be a bold man who says that *anything* could not happen in the second.

J. POTTER

The Reviewers

Mr. D. E. L. Shorter, B.Sc.(Eng.), A.M.I.E.E., is head of the audio-frequency section in the BBC Research Department.

Dr. S. J. McMinn, who is a lecturer in the Department of Structural Engineering, Manchester College of Science and Technology, is an M.Sc., a Ph.D., an A.M.I.C.E., and an A.M.I. Struct. E.

Mr H. E. Kearsey, who is deputy chief engineer of Huntley and Palmers Limited, is an A.M.I. Mech. E., an Associate of the Institute of Cost and Works Accountants and a fellow of the Work Study Society. He is also honorary education officer of the Work Study Society, and a member of various committees on work Study and management.

Mr. James Potter has recently retired after spending thirty-eight years with Cable and Wireless Limited. During the last 9 or 10 years he was in charge of the department concerned with the circulation of traffic.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given though distribution is sometimes restricted.

Safety

Fumes. AIR CONTROL INSTALLATIONS LTD., Victoria Road, Ruislip, Middlesex. The Fumeguard extraction hood for pot type furnaces; six sizes for pots from 10 in to 23 in diameter. Leaflet.

Smoke Alarm. LONDEX LTD., Anerley Works, 207 Anerley Road, London, SE20. Photoelectric smoke density and alarm units for industrial chimneys. Illustrated folder.

Leak Detection. METAL AND PIPELINE ENDURANCE LTD., Artillery Mansions, Victoria Street, London, SW1. Mapel leak detection service for underground pipes or vessels. Leaflet.

Materials

Reinforcement. RICHARD HILL LTD., Middlesbrough. Maxweld fabric reinforcing material, made of hard drawn steel wire, in rolls or sheets. Gauges from 4/0 to 10, and mesh from 3 in to 12 in. Booklet gives floor boardings and slab thicknesses for various spans and types of building.

Packing Paper. BOWATER-EBURITE FIBRE CONTAINERS LTD., Purley Way, Croydon, Surrey. Single-faced corrugated wrapping paper as rolls, cut sheets, folding cartons, etc. Strawpaper, Kraft backed or white poster. Folder.

Chipboard. BRITISH PLIMBER LTD., Dovers Corner, New Road, Rainham, Essex. Physical properties of chipboard as a building material. Also methods of painting, etc. Illustrated brochure.

Nickel Alloy Steels. MOND NICKEL CO. LTD., Thames House, Millbank, London, SW1. Atlas of isothermal transformation characteristics of nickel steels; isothermal diagrams and continuous cooling transformation diagrams for oil quenching with notes on the phases and a bibliography. 90 page booklet (third edition).

Separators. KNITMESH LTD., 36 Victoria Street, London, SW1. Knitted material (metal or plastics) for making strainers, demisters, separators, seals and the like. Various pamphlets.

Explosives. IMPERIAL CHEMICAL INDUSTRIES LTD., Imperial Chemical House, Millbank, London, SW1. Regulations and recommendations for the sale, storage and conveyance by road of explosives. Booklet, third edition.

Aluminium Honeycomb. CIBA (A.R.L.) LTD., Duxford, Cambridge. Aeroweb aluminium honeycomb material for light weight construction. Looseleaf design information sheets giving particulars for various types of loading.

Fire Hoses. IMPERIAL CHEMICAL INDUSTRIES LTD., Imperial Chemical House, Millbank, London, SW1. Terylene for use in fire hoses; its lightness, strength and rot resistance. Booklet.

Injection Moulding Materials. BX PLASTICS LTD., Higham Station Avenue, Chingford, Essex. General characteristics of Bextrene and Bexoid materials for injection moulding. Brochure.

Sealing Paste. D. C. LONCRAINE & CO. (JIFFYTEX) LTD., Barrow Works, Pewsey, Wilts. Jiffybind paste for sealing frayed or cut ends of fabrics such as carpets, etc. Supplied in tubes. Leaflet.

"Difficult Materials." DANIEL DONCASTER AND SONS LTD., Penistone Road, Sheffield. Illustrated brochure "The manipulation of difficult wrought materials" describes the working and forging of titanium, nimonic, alloy steels, zirconium, and others.

Asbestos Slabs. CAPE ASBESTOS CO., LTD., 114 Park Street, London, W1. Caposite asbestos slabs for insulating flat surfaces; data sheet gives sizes and conductivity figures.

Strip and Wire. FIRTH CLEVELAND STEEL STRIP LTD., Tipton, Staffs. Cold-rolled strip and wire in various steels and sizes. Physical properties and analyses given in brochure.

On the Shelf

By Frank H. Smith

In November, 1958 (I'm not late—I've only just seen it) the Electrical Development Association (2 Savoy Hill, London, WC2) produced its first quarterly illustrated newsletter entitled "Electrified Production." It's only four pages but I suppose they feel it is worth it.

Betcha don't know what BISITS are—or is. British Iron and Steel Industry Translation Service (BISRA, 11 Park Lane, London, W1). They are issuing "periodical notices grouping together details of papers on specific subjects." (It's getting foggy again.) Now I see that although they give the Park Lane address at the head of the guff, the accompanying press release comes from the Iron and Steel Institute. Try them if you want more news. At 4 Grosvenor Gardens, London, SW1. Thank heaven I'm not a busy editor trying to make a deadline. (I'm just a columnist trying to make a breadline.)

If you want to attend the first conference of the British Computer Society Limited (a funny mixture in a title) at Cambridge, 22/25 June, write to them at University Mathematical Laboratory, Corn Exchange Street, Cambridge.

There are people who collect cumulated indexes (better than matchbox covers they say) so I offer them Index to the Scientific Proceedings of the Royal Dublin Society, 1910-1949, Volumes 12 to 25. Price 10*s* from the RDS at Ball's Bridge, Dublin. I wonder who Ball was?

Now and again I pop a little bit in this column that is not quite relevant to the matter in hand (if you can trace any relevance anywhere) in the hope that my censor at 36 Bedford Street loses his (her?) place during the coffee break and passes it in error. Such a piece is this about a most colourfully covered booklet from Trust Houses. I suppose engineers do take holidays and they will find this booklet most useful. General information, a list of Trust Houses in the town order with listings of facilities easily coded, four road maps and an explanation of their meal voucher system. There are 230 of these houses scattered here and there and the booklet is available from 53 Short's Gardens, London, WC2—on the house.

Edward Stanford, the mappers, have issued their bulletin No. 12 (January). 12-4 Long Acre, London, WC2. If anybody is thinking of going to Budapest they've a new street plan with legend and index in English. Also a new line in large scale maps of Northern Ireland and a guide to Moscow.

The Union of International Associations has a long memory and from their offices at Palais d'Egmont, Brussels, they remind me that last year we had correspondence which has led them to send me a folder announcing the "Yearbook of International Organizations 1958-9." Engineering bodies are strongly represented and this book of reference can be obtained (78*s*) from E. S. Rew, Esq., 91 Lyndhurst Gardens, Finchley, London, N3, who will be pleased to provide publicity material explaining the contents of the book. A favourable feature to most of us is that whereas last year's edition was in French, this year's is in English. Most of us can read English (even though some of us cannot write it).

When I mentioned the catalogues of the Central Film Library (Government Building, Bromyard Avenue, Acton, W3) recently, I think I omitted to say that "the Catalogue of 16 mm Silent Films" cost one shilling, "Films for Industry" costs 2*s* 6*d* and "Catalogue of Sound Films" is 3*s* 6*d*. Worth it though.

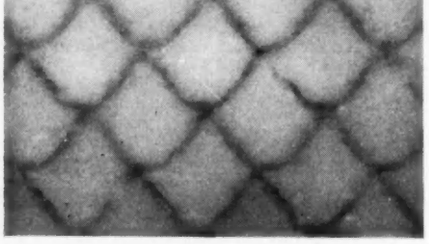
I do enjoy reading local libraries' chit chat bulletins and no exception is that of Islington. I do envy those boroughs whose librarians issue these guides to what is worth reading month by month. But I suppose the result is a whacking great waiting list from the feather-bedded ones, which is rather unfair on those who trouble to browse round the shelves themselves.

Metals and Materials

TERYLENE-RUBBER CONVEYOR BELTING

Nearly six miles of rubber-covered belting designed and manufactured by BTR Industries Limited, Vincent Square, London, SW1—some of it almost certainly the widest and thickest ever made—is now on its way to a large ore field in the Soviet Union. This installation is believed to be unique in that it is the first application of 100 per cent Terylene fabric in a major conveyor system. The special heavy fabric was woven to BTR design from 376,000 lb of yarn. The belting has been supplied in three widths; 1,400 mm, 1,600 mm and 2,000 mm, and shipped in fifty rolls each about 180 metres (590 ft) long. It is made up of 8 to 14 plys of Terylene fabric with skim coats between plys—the widest belting with a 6 mm thick top cover including a nylon transcord breaker and a 2 mm thick back cover.

Terylene was chosen for the job because it is the fibre having the best combination of outstanding strength whether wet or dry, flexibility and resistance to impact, stretching, abrasion and rot. The maximum working tension in the wide belting is 60,000 kg (59 tons) and is capable of transmitting in excess of 1,000 h.p. The belts are being vulcanised endlessly on-site in the USSR with equipment designed and supplied as part of the contract.



HONEYCOMB FLAW DETECTION

The accompanying thermograph of a brazed stainless steel honeycomb panel clearly reveals the underlying core structure. Experimental work at the Martin Company's Division at Baltimore 3, Maryland, USA, indicates that temperature patterns of this sort may open up an easy, accurate way to detect flaws in composite panels.

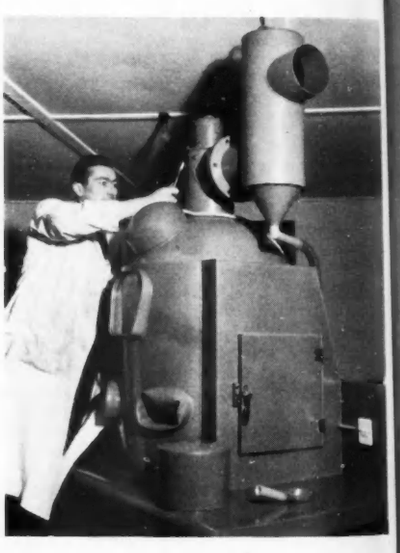
Martin are studying the technique for possible use in continuous inspection or quality control work. The top surface of the specimen is coated with an oil film and infra-red heat is applied underneath. The heat travelling upward along the most conductive path displaces the surface film in a pattern that reflects the arrangement of the conductive material. Applied to composite panels, the heat is conducted by the honeycomb core so that the temperature pattern which appears on the top skin is a picture of the honeycomb core where it is joined to the skin.

Thermographs clearly show irregularities in cell patterns, excess agglomeration of brazing material at junctions and the intimacy of the core-to-skin contact. They provide an instantaneous, extended coverage picture that can be interpreted visually or photographed. Present external inspection methods, notably the sonometer and stubmeter, indicate the soundness of a bonded structure only locally and indirectly.

PLASTICS IN NEW VAPOUR BLASTING EQUIPMENT

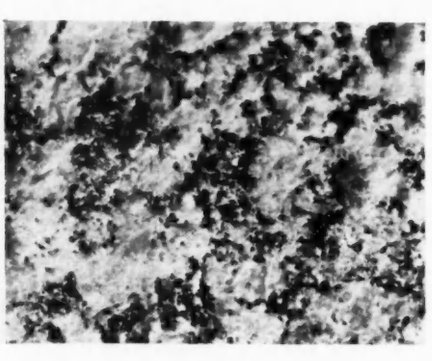
A new type of vapour blasting equipment marketed under the trade name Hydrotron by Metachemical Processes Limited, of Crawley, Sussex, is fabricated from Vybak Industrial rigid pvc sheet made by Bakelite Limited. The Hydrotron comprises basically a pvc blasting cabinet and supporting structure, beneath which is located a large polyethylene container for holding the abrasive slurry. Compressed air is used to displace the slurry from the container to the blasting gun housed in the cabinet. Other uses of plastics in the design include rigid pvc for the extractor unit with nylon for the impeller, and rubber for built-in sleeves to protect the operator's hands.

A number of functional advantages are claimed for the Hydrotron; the abrasive within the slurry cannot be contaminated by the rigid pvc used in the construction of the equipment, and abrasives, or grades of slurry, can be altered in a moment merely by changing to another polyethylene container. Almost every cleaning or etching technique can be replaced by this new method and all metals that are in any way capable of being plated can, it is claimed, be prepared by Hydrotron blasting. The freedom from contamination resulting from use of plastics is said to be especially important in preparation for plating of such metals as molybdenum, uranium and titanium.



FLAME FINISH FOR GRANITE

A surface finish for granite, described as " beautiful and vibrant," may be produced by applying intense heat to the surface. The Linde Department of Union Carbide International Company, 30 East 42nd Street, New York 17, USA, have called the method Thermal-Texturing, and they expect it will be attractive not only because of the appeal of the surface texture (see illustration) but also because it allows the faces of granite veneers as thin as $\frac{3}{8}$ in to be prepared without cracking, hence with advantage both in material and transportation costs.



Successive parallel sweeps are made over the granite with a 6,000° F oxy-acetylene flame, the torch head being held about 1 in from the surface of the granite. This treatment results in controlled spalling which leaves the mica and biotite constituents standing proud of the feldspar and quartz. By varying the flame angle, speed and direction of traverse, and distance of the flame above the granite, distinct differences in texture can be produced. " Most dramatic effects with Thermal-Texturing," say Linde, " are obtained in treating coarse grained granites, but the new process is also effective on fine grained material." Linear speeds of from 24 in to over 100 in per minute are practical, which with an effective flame width of 4 in means that coverage ratios of up to about 180 sq. ft per hour are possible.

NICKEL STRIPPING BATH

Niplex is a new non-electrolytic bath that allows nickel to be stripped from all metals, including zinc base or copper plate, without impairing the underlying surface. It is already in use in the United States and Germany. The stripping rate of a fresh bath at room temperature is approximately 0·0025 in of nickel per hour, but this can be accelerated to a maximum of 0·006 to 0·009 in per hour by heating the bath. Niplex solution is said to contain no cyanide, caustic or acid, not to fume, and to be stable for long periods. In normal use no analytical control is necessary except for replacing evaporation losses with water. Full details may be obtained from the European Metal Finishing Division of Roto-Finish Limited, Mark Road, Hemel Hempstead, Herts.

Operation and Maintenance

DUST AND GRIT IN FLUE GASES

Gravimetric Sampling of Solid Particles

*By R. A. Granville, B.Sc., A.Inst.P., and W. G. Jaffrey, B.Sc.**

The Clean Air Act has increased the need for a practical method of measuring the concentrations of solids in flue gases. It is necessary that such measurements should be made rapidly, to show the variations which may occur, because the collection efficiencies of many types of gas cleaning plant are influenced by the concentration of solids in the inlet gases. Moreover, if it is possible to relate a change in the process to the change of solids concentrations in the effluent gases, methods of control may be devised and can then be quantitatively tested. The apparatus which is described here is available commercially.

To obtain a representative point sample of a stream of flue gas in which solid particles are entrained, it is necessary to aspirate the gas so that it flows into the sampling nozzle at the same speed and in the same direction as the local velocity in the main gas stream. This is known as isokinetic sampling. The errors arising from anisokinetic sampling have been described [1-4] but it is sufficient to note that the error in an assessment of the solids concentration (calculated from the mass collected and the volume of the gas sample) is normally less than the error in the sampling rate. The practical difficulties of obtaining this representative point sample, or a sufficient number to describe the whole flue gas stream in an adequate manner, arise in three ways. These are: (i) stratification—the variation of solids concentration from point to point across the flue; (ii) solids concentration variation with time—occurring through process instability or deliberate process change; and (iii) flue gas velocity variation with time and position.

If we consider the independent effects of these three phenomena, the first requires that sampling should be carried out at several points across the flue. The second restricts the time available for sampling, if variations in concentration are to be assessed, whilst the third requires that the sampling rate be adjusted to maintain isokinetic conditions. An apparatus which was originally devised for rapid sampling in hot corrosive flue gases containing micron and submicron sized fume particles, has now been developed and can be used for measuring concentrations of fume, dust and grit.

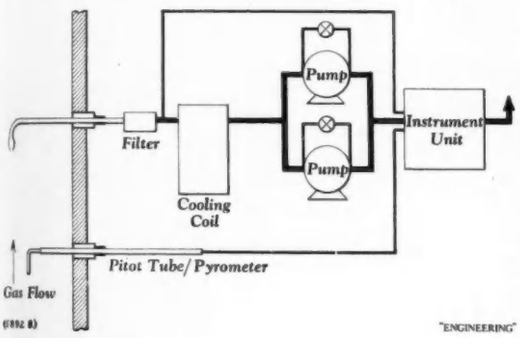


Fig. 1 Arrangement of sampling apparatus.

The apparatus consists of a set of sampling nozzles, a sampling probe, a filter unit, a cooling coil, an extractor pump, a flowrate indicator and integrating meter with thermometer, an NPL pitot-static tube incorporating a thermocouple, an inclined gauge, a millivoltmeter and a suction gauge. An arrangement diagram is given in Fig. 1 and the components in Figs. 2-6. Everything required at site, with the exception of a stopwatch, is included. The items which comprise the entire sampling apparatus have been grouped into units and fitted into separate cases.

The flowrate indicator and integrating meter have been placed on the outlet side of the gas-tight extractor because in this position they are unaffected by the pressure change across the filter unit, which increases as solids are trapped on the fibres. It is therefore unnecessary to apply progressive corrections to the meter readings whilst sampling. Detailed descriptions of the components and units are given in Appendix 1 and photographs of them are shown in Figs. 2 to 6.

* British Iron and Steel Research Association.

Site Selection

The first requirement of a sampling site is that it should be as near as possible to the position at which it is required to measure the solids concentration. For example, if it is desired to know the amount of solids passing to atmosphere, measurements in a chimney will indicate this with fair accuracy as long as the gas velocity is greater than the settling speeds of the solid particles, but if there are many bends or an obstruction such as a recuperator or damper between the sampling point and gas exit, some solids may be deposited and therefore will not reach the atmosphere.

The best guide to a suitable location is obtained by measuring the gas flow distribution, and a preliminary survey of the flow distribution should always precede the final planning of solids concentration measurements. An ideal location is one in which the gas flow is vertically upwards and the distribution is uniform across the flue at all flowrates likely to be encountered during a test. A bowed or an asymmetrical distribution is acceptable although it will increase the difficulties of sampling if the maldistribution is severe. Sampling should not be attempted if at any point across the sampling plane the flow is found to be in the reverse direction to the main flow.

It is not easy to prescribe rules for selecting a location, but a position not less than five duct diameters downstream of any bend or obstruction or three diameters upstream should be chosen whenever possible. The gas flow through flues or ducts at industrial plant is invariably turbulent and if, at locations remote from bends or obstructions, the mean velocities are greater than about 20 ft per sec, the flow distribution patterns are often similar although the total flowrate may vary. Where this constancy of flow pattern does exist, it permits simplification of the sampling procedure, and it can be determined by comparing, for the range of total flowrates likely to be encountered during a test, the ratios of velocities at fixed points to the mean velocity in the flue.

When the sampling location has been chosen, three sampling holes should be made in circular flues, equispaced (at 120° intervals) around a common circumference. If it should be impossible to make three holes or obtain access to them, two holes should be made at 90° to each other. One of these holes should be sited at the top of the flue if it is not vertical, so that the sampling probe and pitot tube can be traversed to the lowest point in the flue. To sample in rectangular flues, two holes should be made in the longer face, near to the corners, and a third hole on the centre line. A fourth hole should be made on the centre line of the shorter face. The manner in which these sampling holes should be made and prepared to receive the probes is described in Appendix 1.

A preliminary survey of the process and the flow distribution across the flue enables the operator to assess the length of time during which conditions appear to be reasonably steady. It is also then possible to choose a sampling nozzle so that the sampling flow rate will be between 2 and 3 cu. ft per min at the meters. In Table I flowrates are given for nozzle diameters of $\frac{3}{4}$ in, $\frac{1}{2}$ in and $\frac{5}{8}$ in and stream velocities from 1 to 10 ft per sec, from which flowrates for any gas velocity can be calculated by summation. In Appendix 2 the calculations of flue gas density and velocity, isokinetic sampling rate and dry sample volume are shown in detail, and in Appendix 2 (5) an example is given to illustrate how this method can be employed in preparing a simple two-column table relating the indicated flowrate Q_m to the pitot tube signal Δ_p for a given nozzle diameter, flue gas temperature and pressure. A set of these tables is prepared before sampling, sufficient to cover the range of conditions which may be encountered.

A recommended procedure for sampling in the flues or chimneys at electricity generating stations has been given in BS 893,[5] but is unsuitable for investigating the solids concentration in flue gases at plants which do not operate steadily for a minimum period of 6 hours.

When sampling in flues in which the gas flow is evenly distributed and it is known that particles greater than about 10 microns diameter will not be present, there is an excellent prospect of sampling at one fixed point and obtaining a measure which will be representative for the total gas flow. Measurements at the chimneys of open-hearth furnaces which are equipped with waste-heat boilers[6] and at a pneumatic steelmaking plant have proved amenable to single point sampling by preliminary estimations of the degree of stratification using two sampling trains operating simultaneously. It is reasonable to suppose that a similar procedure would prove satisfactory in other cases. Provided the plant operation is steady for a sufficient period of time, estimates of the degree of stratification may be obtained by rapidly sampling at three or five points across a flue, taking each sample into separate filters. Particular care should be taken to include in this assessment samples taken near the lower face of non-vertical flues, in the corners of flues with a rectangular cross-section and at the outer face of flues which are curving in direction, or downstream from a bend. Before making a traverse across a duct in which the velocity is not uniform, a set of factors should be prepared relating the ratio

Continuing Operation and Maintenance

of the flue gas velocity at the sampling point to the mean or reference velocity indicated by the pitot tube. These can then be applied to the prepared sampling tables relating Q_m to Δ_p by direct multiplication.

Assembly and Use of Apparatus

Before measurements begin an adequate number of filters should be prepared by drying them, in their canisters together with the retaining screens, in an oven for 60 minutes at a temperature of 110° C ± 5° C, cooling in a desiccator and then weighing to an accuracy of ± 2mg. A similar drying and weighing process is employed with the used filters to determine the mass of solids collected. If it is intended to take samples in rapid succession, two outer container assemblies should be loaded with clean and weighed filters. The combined pitot tube and pyrometer is positioned in the flue so that it indicates the mean or some selected reference gas velocity, but will not obstruct the sampling probe or come within less than about 4 in of the nozzle. The sampling probe with the selected nozzle attached is then introduced into the flue with the nozzle at first facing downstream, clamped in position and left with a stopper in the butt end so that flue gases thoroughly warm the probe but do not deposit dust in the nozzle. Other connections in the sampling train should then be made, leaving the filter assembly in position but unattached to the sampling probe. Reference to the millivoltmeter indicating the flue gas temperature and to the inclined gauge enables the indicated isokinetic sampling rate to be obtained from the previously prepared table.

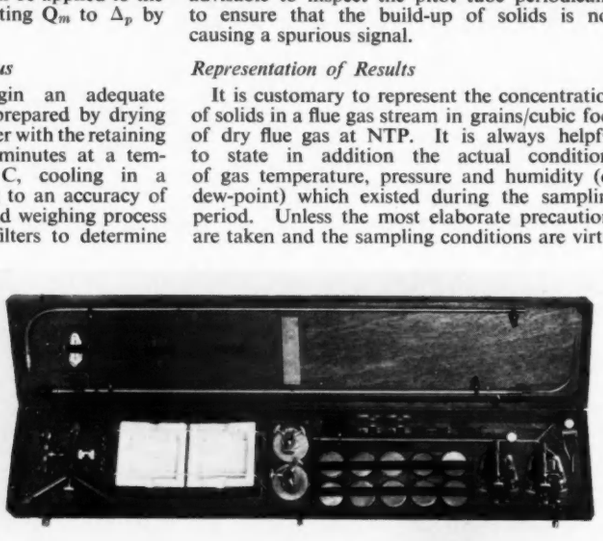


Fig. 2 The sampling nozzles, probe, filters and other items are packed in a carrying case.

To commence sampling, the probe stopper is removed, the filter connected, and the probe rotated so that the nozzle faces into the gas stream. The extractor pumps and stopwatch are then started simultaneously and the sampling rate immediately adjusted to the isokinetic value, where it is maintained for the duration of the sampling period. At the conclusion of the sampling period, or if the pressure loss across the filter should rise in excess of 4 lb per sq. in, the extractor pumps and stopwatch are switched off, the filter assembly is at once uncoupled from the probe and outlet connector, and the integrating meter reading entered on the report sheet. If a second filter assembly has been prepared it may be coupled to the probe and outlet connector, and sampling resumed with a minimum of delay.

The used filter assembly should be supported with its inlet vertical and any material adhering to the inlet pipe brushed into the filter. When the top part of the outer casing has been removed, any material on its inner face should also be brushed into the filter before it is removed in its canister for drying and reweighing. Provided the probe has become sufficiently warmed by the flue gas before sampling is commenced, the amount of solids retained inside the sampling probe has been found to be less than about 1 per cent of that collected in the filter.

When no previous experience is available to the operator it is advisable to check the magnitude of this loss by periodically cleaning the probe with the brush and pull-through on to a sheet of glazed paper. The solids should be transferred to a suitable container and weighed separately with the filters which were used during the period in which the solids were deposited in the probe. The pitot tube has been found to remain unblocked and in satisfactory operation despite 20 hours continuous use in the chimney gases of an open hearth furnace where the average solids concentration was about 0·2 grains per cu. ft at NPT. It is nevertheless advisable to inspect the pitot tube periodically to ensure that the build-up of solids is not causing a spurious signal.

Representation of Results

It is customary to represent the concentration of solids in a flue gas stream in grains/cubic foot of dry flue gas at NTP. It is always helpful to state in addition the actual conditions of gas temperature, pressure and humidity (or dew-point) which existed during the sampling period. Unless the most elaborate precautions are taken and the sampling conditions are virtually ideal, it is not possible to measure the concentration of solids in a stream of flue gas to a better accuracy than 5 or 10 per cent. It is, therefore, rarely necessary to express the final data to more than two significant figures.

If the process which has been investigated is of a cyclic nature, the solids concentration, flue gas temperature and discharge rate can be plotted against the time from the beginning of the cycle, to illustrate any trends that may exist. When several series of measurements have been taken, throughout the process cycle, it is also useful to divide the cycle into a number of periods and plot the data obtained during each of these periods in the form of a histogram with the number of measurements as the ordinate and the measured quantity as the abscissa. Results shown in this form[6] clearly illustrate the extent and type of variations which occur at similar stages of a process.

Acknowledgments

This apparatus has been designed as part of the British Iron and Steel Research Association's research programme into the investigation and control of air pollution at iron and steelworks, undertaken in collaboration with the Air and River Pollution Committee of the British Iron and Steel Federation. The authors wish to acknowledge the assistance given to them by this committee and by the Longworth Scientific Instrument Company, who undertook the final development and manufacture of the apparatus.

REFERENCES

[1] Badzioch, S. Brit. Coal Util. Res. Assoc. Members' Information Circular No. 174. Private communication, 1957.

[2] Davies, C. N. *Dust is Dangerous*, Faber and Faber Ltd., chapter 2.

[3] Watson, H. H. Amer. Ind. Hyg. Assoc. Quarterly, p 1 vol 15 (1954).

[4] Haines, G. F., and Hemeon, W. C. L. Information Circular No. 5 to the American Iron and Steel Institute.

[5] Method of Testing Dust Extraction Plant and the Emission of Solids from Chimneys of Electric Power Stations. British Standard Specification No. 893, 1940.

[6] Jackson, R., and Granville, R. A. "Measurement of Dust in Flue Gases." Iron and Steel Institute Meeting on Air Pollution, 1957.

APPENDIX 1

The Equipment

Sampling Nozzles and Probe (Fig. 2)

Three stainless steel sampling nozzles of ⅜ in, ½ in and ⅝ in diameter are available. With these it is possible to sample flue gases with velocities of 15 ft per sec and more whilst maintaining an adequate flowrate. The tip of the nozzle has the external face chamfered at 30° to the nozzle axis whilst the inside is tapered to match with the internal diameter of the sampling probe. A threaded locking ring is attached and sealed to the end of the probe so that the nozzles can be screwed on by hand.

The probe is fabricated from ½ in bore, seamless, stainless steel tube and incorporates a smooth right angled bend of 4 in internal radius at the nozzle end followed by a straight shank. Its overall length is 5 ft. The butt end of the probe has a slight external taper with a shallow groove around its circumference to enter and lock in a gas tight O-seal attached to the filter inlet connector. At exposed sites in severe weather, or when sampling flue gases with a high dew point, it may prove desirable to insulate thermally the exposed portion of the sampling probe. For this purpose, lengths of tubular lagging are provided.

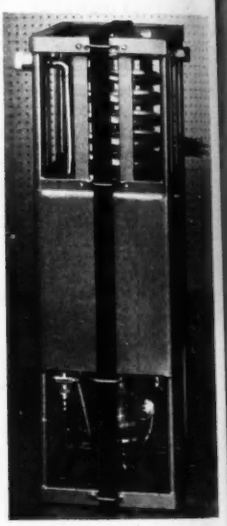


Fig. 3 (left) The composition of the sampling filter.

Fig. 4 (right) The cooling coil assembly.

Table I.—Sampling Rates for Three Nozzle Diameters in Cubic Feet per Minute

Gas Velocity, ft per sec.	Nozzle diameter		
	⅜ in	½ in	⅝ in
1	0·04602	0·0818	0·1278
2	0·0920	0·1636	0·2557
3	0·1381	0·2454	0·3835
4	0·1841	0·3272	0·5113
5	0·2301	0·4090	0·6391
6	0·2761	0·4908	0·7670
7	0·3221	0·5726	0·8948
8	0·3682	0·6544	1·0226
9	0·4142	0·7362	1·1505
10	0·4602	0·8180	1·2783

Filter Unit (Fig. 3)

The filter unit consists of an outer casing in two parts, which carry the inlet and outlet connectors, and an inner canister. A filter pack of

glass fibre is placed inside the canister and retained in position by stainless steel expanded metal screens at the inlet and outlet. The outer casing and the canister are of stainless steel, and the assembly is made gas tight by a silicone rubber O-ring which is compressed against one face of each of the three components by tightening the three clamps. The filter packs are so made that the glass fibres at the entrance to the filter are of a larger diameter than those at the exit end, for this arrangement was found to increase the holding capacity of the filter and to prevent the escape of fine particles. A machine preparation and assembly technique has now been adopted using a composite layer of unbonded glass fibre felt as the raw material. The filter pack in its canister, with the retaining screens, weighs approximately 100 gm.

The assembled filter unit is attached to the probe by inserting the butt end of the probe into the connector until the spring-loaded locking catch is engaged. In this position a full bore gas-tight seal is made and the filter is rigidly attached to the probe. At the outlet end a T-piece connector engages with the filter exit tube and provides a full bore junction with a 4 ft length of hose leading to the cooling coil. This and all subsequent extractor line connectors are similar, comprising an externally tapered tube inside an O-ring, secured with a screw coupling and colour coded. The side arm from the T-piece permits a signal tube to be taken to the gauge in the instrument unit where the suction at the filter outlet is indicated. A hinged lagging box of light construction can be fitted over the filter unit when sampling flue gases with a high dew point at an exposed site. If when using the lagging box more than about 2 ft of the probe extends from the stack, it is advisable to use the probe support stand.

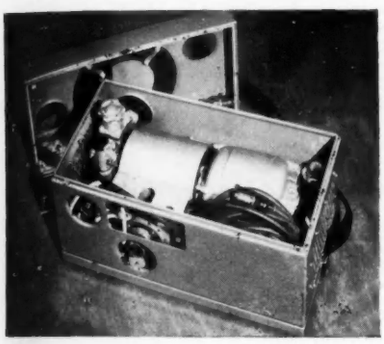


Fig. 5 An extraction pump unit.

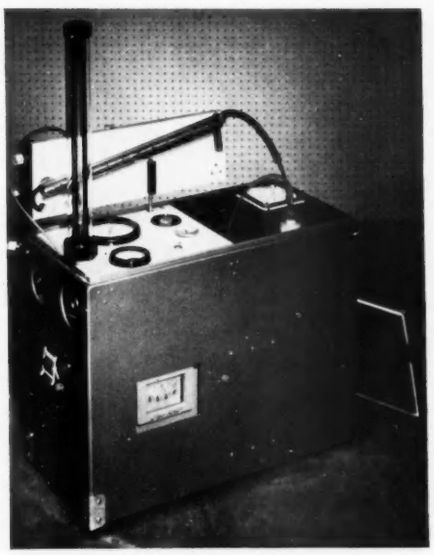


Fig. 6 The instrument case.

Cooling Coil (Fig. 4)

The coil is formed from 24 ft of ½ in bore nickel plated copper tube; the upper part is exposed to the air while the lower is immersed in a water bath. The condensate trap, which consists of a replaceable 2 lb bottling jar, is mounted externally below the base of the water bath and held against a rubber sealing disc by a stirrup and screw clamp. A frame construction is employed to hold the components in position and provide adequate protection to the coil and condensate trap, and a carrying strap is fitted around the whole assembly. It has been found that gases at 400° C can be reduced to within a few degrees of the water bath temperature with this arrangement.

Extractor or Sampling Pump (Fig. 5)

The extractor is a gas-tight vane pump fitted with a diaphragm valve, used as a by-pass, to control the flow rate. It is an adaptation of the Edwards R.B.4 vacuum pump, but housed in a vented carrying box, connected to a 20 ft length of tough rubber-sheathed cable with Niphan connectors, a weatherproof switch and extension cable. To sample gases at rates in excess of 2 cu. ft per min (when reduced to cooling coil temperature and at the reduced pressure after the filter) two pumps are used in parallel. By using the extension cable the switch on either pump can be used to control both of them. These pumps and this arrangement have proved very convenient and adaptable in that two units are more easily carried to the site than one larger one, while the sampling flow-rate can be adjusted over nearly a 2 : 1 ratio with one of the by-pass valves. Despite the very rapid increase in filter resistance that can occur when sampling in heavy concentrations of fume, the pumps are able to draw the required volume against a resistance of more than 5 lb per sq. in, only a little adjustment of the by-pass valve being necessary.

Instrument Unit (Fig. 6)

This unit comprises a box, with lid and carrying strap, containing the necessary meters and gauges for operating the sampling train. The gas first passes through a variable orifice flow-rate meter, which directly indicates the sampling rate, and then through a dry diaphragm gas meter, with a thermometer in the outlet connector, enabling the total volume of the gas sample to be read to an accuracy of 0·1 cu. ft. The gas may be discharged to atmosphere from the rear of the instrument unit but a connection is provided so that a hose can be attached for remote venting should the sampled gas be noxious or offensive. A gauge is included to indicate the pressure drop across the filter and give some guidance to the operator about the amount of solids collected. To operate in conjunction with the combined pitot tube and thermocouple, a millivoltmeter and multi-range inclined gauge are mounted on the top panel of the unit. The sheathed chromel-alumel thermocouple and compensating cable in conjunction with the 0-25 millivoltmeter enables measurements of flue gas temperatures up to 600° C to be made. It is sufficient to measure this temperature to an accuracy of ± 5° C and therefore the thermometer in the integrating gas meter is a sufficient indication of the cold junction temperature.

The inclined gauge is mounted on the top panel of the instrument unit, and during transit is lowered inside the case. Its scale is approximately 12½ in in length divided into 10 units with appropriate subdivisions. The inclination of the gauge can be varied so that a full scale deflection of the gauge fluid corresponds to pressure signals of 0·5, 1·0, 2·0 and 10·0 in water gauge. A screw-controlled zero set is also included and an overflow chamber is attached to the lower pressure side of the gauge. A terminal panel is provided for connecting the leads and signal tubes from the combined pitot tube and thermocouple; these four signal lines are contained in one outer sheath.

Probe Mounts (Fig. 2) and Service Connections

A 4 in BSP socket attached to the flue wall is employed for carrying the sampling probe and pitot-tube mounting plugs. A full-bore hole inside the socket walls is sufficient to admit the probe or pitot tube through unlined or thin walled flues, otherwise some relief to the lining brickwork is required. This relief can take the form of a single channel, about 1 in wide and 6 in deep on the downstream side of the socket, which enables the sampling probe to be inserted facing in a downstream direction.

The mounting plugs for the sampling probe and pitot tube are identical and have a 4 in BSP thread. A tubular support extends from one end and carries three finger screws which permit sufficient adjustment of the probe angle to offset any misalignment which may occur in fixing the sockets and lock the probe in position.

The rubber connecting hoses are of ¼ in bore with ribbed walls for strength and durability. All hose connectors are similar and comprise an externally tapered ½ in bore tube entering a rubber O-ring, the two parts being secured together by a screw coupling. Between the filter outlet and the cooling coil inlet, silicone rubber O-rings are used.

Various motors are available for driving the extractor pumps, depending on the electricity supply from which it is intended to operate. Normally a 230-250 V, 50 cycle, single phase, ¼ h.p. motor is fitted. Provision has been made for connecting a service lamp into each pump circuit, independent of the pump motor switch. A 2 kW supply is sufficient to start and drive two pumps and operate two 100 watt service lamps.

APPENDIX 2

The Calculation of Gas Density, Gas Velocity, Sampling Rate, and Dry Sample Volume

1. *Gas Density in the Duct*

It is assumed that the following information has been obtained by measurement or reference to standard tables:

Density of dry gas, lb per cu. ft at 0° C and 760 mm mercury = ρ_g.

Density of water vapour, lb per cu. ft at 0° C and 760 mm mercury = ρ_w.

(ρ_w = 0·0502 lb per cu. ft, at 0° C and 760 mm mercury).

Temperature of gas in the duct, ° C Absolute = T_d.

Dewpoint of gas in the duct, ° C = θ_d.

Absolute pressure of gas in the duct, mm mercury = P_d.

Saturated vapour pressure (SVP) of water at θ_d ° C, mm mercury = p_d.

Hence:—The proportion by volume of water vapour in the moist gas is equal to

$$\frac{p_d}{P_d} = A_d \quad . \quad . \quad . \quad (1.1)$$

The proportion by weight of water vapour to dry gas is equal to

$$\frac{p_d}{P_d - p_d} \times \frac{\rho_w}{\rho_g} = W_d \quad . \quad . \quad (1.2)$$

Therefore the density of the gas in the duct is equal to

$$[(1 - A_d)\,\rho_g + (A_d)\,\rho_w]\ \frac{273}{T_d}\ \frac{P_d}{760} = \rho_d \quad (1.3)$$

2. *Gas Velocity in the Duct*

If an NPL type pitot tube is used to determine the gas velocity, the following formula may be employed:—

$$V_d = 18{\cdot}3\sqrt{\frac{\Delta_p}{\rho_d}} \quad . \quad . \quad . \quad (2.1)$$

Where:—

V_d = Gas velocity ft per sec.

Δ_p = Pressure difference between the "total head" and "static," pressure tappings on the pitot tube, in in w.g.

ρ_d = Density of gas in the duct, in lb per cu. ft.

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3. *Sampling Rate*

If a sampling nozzle of inside diameter D in has been selected and the local undisturbed gas velocity in the duct is V_d ft per sec, then the volumetric flow into the nozzle is Q_d cu. ft per min, where,

$$Q_d = V_d \times 60 \times \frac{\pi D^2}{4} \times \frac{1}{144} = \frac{V_d \ D^2}{3{\cdot}06} \quad . \quad . \quad . \quad . \quad (3.1)$$

The gas is metered under the following conditions:

Absolute pressure, mm mercury .. $= P_m$
Temperature, °C, absolute .. .. $= T_m$
Dewpoint (equal to the cooling coil temperature), °C .. .. .. $= \theta_m$
SVP of water at θ_m °C, mm mercury $= p_m$

The change of sample volume caused by the condensation of water vapour and changes of pressure and temperature is thus calculated.

Consider $(1 + W_d)$ lb of gas in the duct, which occupy $\frac{1+W_d}{\rho_d}$ cu. ft. This mass of gas is reduced at the meter to $\frac{1 + W_m}{\rho_m}$ cu. ft, where:—

$$\rho_m = [(1 - A_m)\ \rho_g + (A_m)\ \rho_w] \times \frac{273}{T_m} \frac{P_m}{760} \text{ lb per cu. ft.} \quad (3.2)$$

and

$$W_m = \frac{p_m}{P_m - p_m} \times \frac{\rho_w}{\rho_g} \quad . \quad . \quad (3.3)$$

and

$$A_m = \frac{p_m}{P_m} \quad . \quad . \quad . \quad (3.4)$$

To maintain isokinetic conditions at the nozzle, the sampling flow at the meter is Q_m, where,

$$Q_m = Q_d \left[\frac{1 + W_m}{1 + W_d}\right] \frac{\rho_d}{\rho_m} \quad . \quad . \quad (3.5)$$

4. *Dry Sample Volume at 0° C, 760 mm mercury*

The total sample volume recorded on the integrating meter is reduced to a standard volume Q_0 where,

$$Q_0 = Q_m \frac{1}{1 + W_m} \frac{\rho_m}{\rho_g} \quad . \quad . \quad . \quad (4.1)$$

5. *Indicated Sampling Rate as a Function of Pitot Tube Signal*

In those cases where a gas contains relatively little water vapour, (e.g. a dewpoint less than 40° C), a "cold sampling rate" estimated from the changes in gas temperature and pressure between the duct and meter is sufficient to ensure that sampling is conducted close to isokinetic conditions.

Let it be assumed that ½ in sampling nozzle is to be employed, the duct gas temperature is 250° C and that at the meter the sample is at a temperature of 20° C and atmospheric pressure. It will also be assumed that the pressure in the duct is atmospheric since this frequently occurs in practice.

Firstly we relate V_d in ft per sec to Δ_p by the formula

$$V_d = 18{\cdot}3 \sqrt{\frac{\Delta_p}{\rho_d}}$$

Assuming that the duct gas composition is similar to air

$$\rho_d = 0{\cdot}0807 \times \frac{273}{(273 + 250)}$$

therefore

$$V_d = 89{\cdot}0\sqrt{\Delta_p}$$

The isokinetic flow (at the nozzle) is therefore

$$Q_d = \frac{V_d \ D^2}{3{\cdot}06} = \frac{89{\cdot}0 \times (\frac{1}{2})^2 \times \sqrt{\Delta_p}}{3{\cdot}06}$$

The indicated flow is therefore

$$Q_m = Q_d \times \frac{T_m}{T_d} = \left(\frac{89{\cdot}0 \times (\frac{1}{2})^2}{3{\cdot}06}\right) \times \left(\frac{273 + 20}{273 + 250}\right) \sqrt{\Delta_p}$$

whence, $Q_m = 4{\cdot}07 \sqrt{\Delta_p}$

where Q_m is in cu. ft per min and Δ_p is in inches w.g.

This relationship can then be tabulated for the range of Δ_p which has been shown to exist by the preliminary flow survey. It can be seen that if much work of this sort is required, it would ultimately save labour to prepare sets of curves relating V_d to Δ_p for a range of temperatures. For any one of the three nozzle sizes and values of V_d, the sampling rate at the nozzle, Q_d, can be calculated from the figures in Table I and thus related to Δ_p. The conversion of Q_d to Q_m would then require the evaluation and use of only one temperature factor (assuming T_m to remain constant or nearly so) and the final Q_m and Δ_p tables could be drawn up with a minimum of labour.

Engineering at Home

ENGINEERING TOOLS *for the* HOME CRAFTSMAN

At the Practical Householder Exhibition, held at Earls Court last week, it was noticeable that engineering tools for the home craftsman are reaching a high quality. The standard motorised hand drill, which in recent years has become an indispensible item in the handyman's tool kit, has taken on a new life as the power source for tool attachments which will do almost every kind of job in the home—in the workshop, in the garden, and in the kitchen.

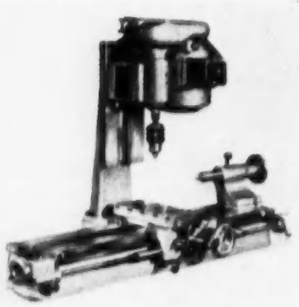
There are scores of these attachments: wood lathes, metal lathes, circular saws, jig-saws, rotary and reciprocating sanders, grinders, buffers, hedgecutters floor polishers, whisks etc., and now, with the new S. N. Bridges gearbox, the precision and range of applications have been extended still further. This gearbox satisfies a need for some means of reducing the speed of the electric drill for certain jobs such as masonry cutting, tank cutting, and drilling hard metals and woods. The off-load speed of most drills is about 3,000 r.p.m.; with the Bridges Nu-Gear attachment this can be reduced to about 750 r.p.m.

Bridges drill with two-speed gearbox attached.

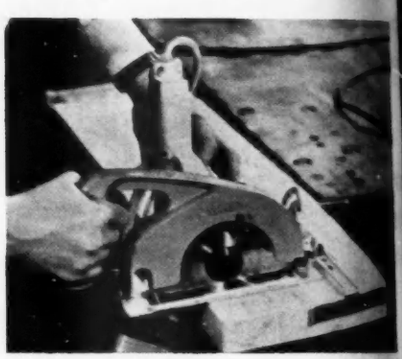
Another drill, which has a built-in speed change attachment, is the Selecta 4500. However, the speed range of this drill (2,500 to 4,500 r.p.m.) is still too high for some jobs. Attachments for this drill have a serious engineering look about them and they are claimed to be highly suited to precision model making and light engineering in metal.

A drill which eliminates the need for an earth wire and thus affords maximum safety from electric shock is the Wolf "Safetymaster." The motor of the "Safetymaster" has no metallic contacts—the armature shaft is completely shrouded in an insulating sleeve and the outer casing of the unit has a moulded insulating lining to ensure that there can be no electrical contact with the operator of the drill.

Selecta kit—ideal for the model maker.



Wolf "Safetymaster" with circular saw attached.



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